CHAPTER 3 AFFECTED ENVIRONMENT

3.0 Introduction

Chapter 3 describes the natural and human environment and resources potentially affected by the alternatives described in Chapter 2. The information presented in Chapter 3 represents a general summary of the potentially affected environment for which the impact analysis in Chapter 4 will use as the environmental baseline.

3.1 Physical Environment

The following discussion presents a broad summary of the physical environment of the Pacific Ocean. The dynamics of Pacific Ocean's physical environment has direct and indirect effects on the occurrence and distribution of life in marine ecosystems.

3.1.1 The Pacific Ocean

The Pacific Ocean is world's largest body of water. Named by Ferdinand Magellan as *Mare Pacificum* (Latin for peaceful sea), the Pacific Ocean covers over a third of Earth's surface (~ 64 million sq miles). From North to South, its over 9,000 miles long, and from east to west, the Pacific Ocean is nearly 12,000 miles wide (on the Equator). The Pacific Ocean contains several large seas along its western margin such as the South China Sea, Celebes Sea, Coral Sea, and Tasman Sea.

3.1.2 Geology and Topography

The theory of plate tectonics provides that there are several plates above the hot, molten lava core of Earth. Figure 1 is schematic diagram of the Earth's tectonic plates. These plates are made of different kinds of rock with varying densities and can be thought of as pieces of a giant jigsaw puzzle– where the movement of one plate affects the position of another. Tectonic processes and plate movements have defined the contours of the Pacific Ocean. Generally, the floor of the Pacific Ocean basin is relatively uniform, with a mean depth of about 4270 m (14,000 ft) (Tomzack and Godfrey 2003). Dotting the Pacific basin, however, are underwater mountain chains, seamounts, islands, underwater valleys and trenches which affect the movement of water and occurrence and distribution of marine organisms.

Generally, the topography of the Pacific Ocean is the result of boundary movements of the Pacific Plate. Divergent boundaries or "sea floor spreading" occurs as the crust of the Pacific Plate pulls apart and forms a hot spot. The resulting molten lava released in the ocean builds up and spreads outward from the hot spot and long island chains are formed when the plate moves over the hot spot source[2]. A well known example of sea floor spreading is the formation of the Hawaiian Islands and the Emperor Seamounts, which when connected, form a 6,000 mile chain[3].

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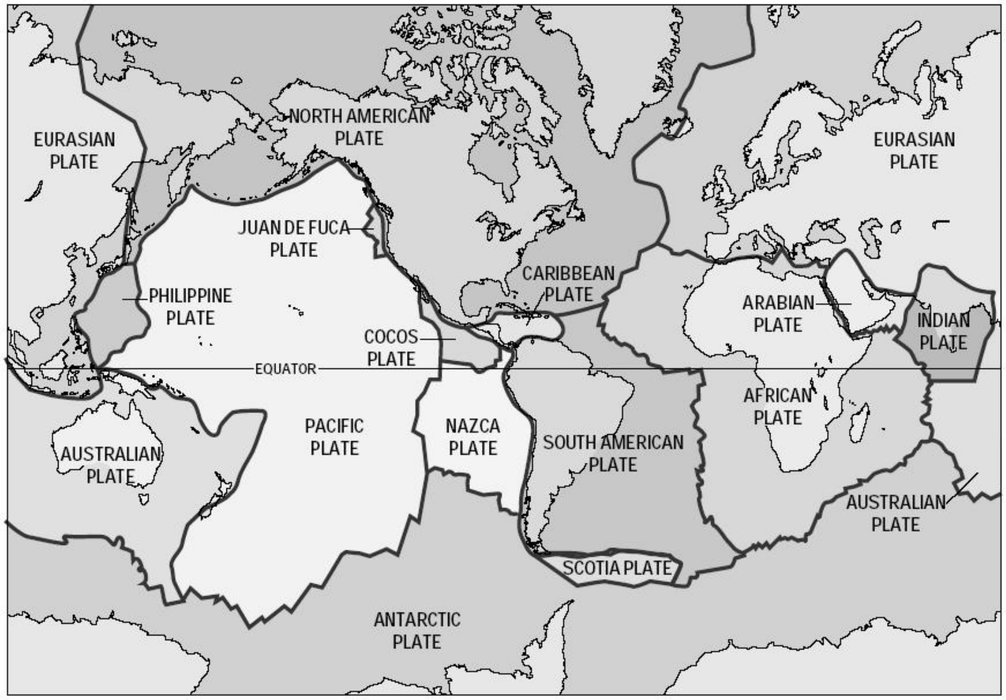
[2]http://www.washington.edu/burkemuseum/geo_history_wa/The Restless Earth v.2.0.htm
[3] http://pubs.usgs.gov/publications/text/Hawaiian.html

Figure 1: Earth's Tectonic Plates
(Source: US Geological Survey)



Convergent boundary movements—the subduction of the Pacific Plate under less dense plates—can produce island arcs as well as deep trenches such as the Mariana Trench, which at nearly 36,000 ft, is the deepest point on Earth. Convergent boundary movements also result in the formation of island arcs, where the denser plate subducts under a less dense plate and begins to melt under the pressure. The formed lava is then released by convection and the result is the formation of island archipelagos.[4]

The Pacific Ocean contains nearly 25,000 islands which can be simply classified as high islands or low islands. High islands, like their name suggests, extend higher above sea level, and often support a larger number of flora and fauna and generally have fertile soil. Low islands are generally atolls built upon layers of calcium carbonate which was secreted from reef building corals. Over geologic time, the rock of these low islands have eroded or subsided to where all that is remaining near the ocean surface is the secreted calcium carbonated produced by reef building corals (Nunn 2003).

3.1.3 Ocean Water Characteristics

Over geologic time, the Pacific Ocean basin has been filled in by water produced by physical and biological processes. A water molecule is the combination of two hydrogen atoms bonded with

[4] http://www.washington.edu/burkemuseum/geo_history_wa/The Restless Earth v.2.0.htm

one oxygen atom. Water molecules have asymmetric charges exhibiting a positive charge on the hydrogen sides and a negative charge on the oxygen side of the molecule. This charge asymmetry allows water to be an effective solvent, thus the ocean contains a diverse array of dissolved substances. Relative to other molecules, water takes a great deal to heat to change temperature, and thus the oceans have the ability to store large amounts of heat. When water evaporation occurs, large amounts of heat are absorbed by the ocean (Tomzack and Godfrey 2003). The overall heat flux observed in the ocean is related to the dynamics of four processes: a) incoming solar radiation, b) outgoing back radiation, c) evaporation, and, d) mechanical heat transfer between ocean and atmosphere (Bigg 2003).

The major elements (> 100 ppm) present in ocean water include chlorine, sodium, magnesium, calcium, and potassium, with chlorine and sodium being the most prominent, and their residue (sea salt- NaCl) is left behind when sea water evaporates. Minor elements (1- 100 ppm) include bromine, carbon, strontium, boron, silicon, and fluorine. Trace elements (< 1 ppm) include nitrogen, phosphorus, and iron (Levington 1995).

Oxygen is added to sea water by two processes: 1) atmospheric mixing with surface water, and 2) photosynthesis. Oxygen is subtracted from water through respiration of bacterial decomposition of organic matter (Tomzack and Godfrey 2003).

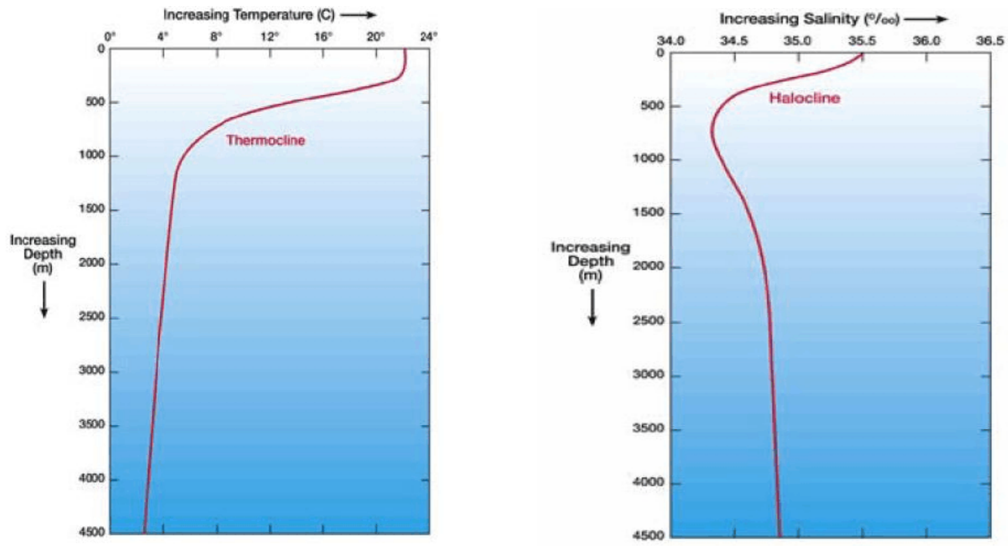
3.1.4 Ocean Layers

Based on the effects of temperature and salinity on the density of water (as well as other factors such as wind stress on water), the ocean can be separated into three layers: the surface layer or mixed layer, the thermocline or middle layer, and the deep layer. The surface layer generally occurs from the surface of the ocean to depth of around 400 m or less depending on location (e.g. 0-150 m in the central Pacific) and is area where the water is mixed by currents, waves, and weather. The thermocline is generally from 400 m - 800 m and where water temperatures significantly differ from the surface layer; forming a temperature gradient which inhibits mixing with the surface layer. Over 90 percent of the ocean by volume occurs in the deep layer, which is generally below 800 m and consists of water temperatures around 0-4 degrees Celsius. The deep zone is void of sunlight and experiences high water pressure (Levington 1995).

The temperature of ocean water is important to oceanographic systems. For example, the temperature of the mixed layer has an affect on the evaporation rate of water into the atmosphere, which in turn is linked to the formation of weather. The temperature of water also produces density gradients within the ocean which prevents mixing of the ocean layers (Bigg 2003). See Figure 2 for a generalized representation of water temperatures and depth profiles.

The amount of dissolved salt or salinity varies between ocean zones as well as across oceans. For example, the Atlantic Ocean has higher salinity levels than the Pacific Ocean due to input from the Mediterranean Sea (several large rivers flow in the Mediterranean). The average salt content of the ocean 35 ppt, but can vary at different latitudes depending on evaporation and precipitation rates. Salinity is lower near the equator than at middle latitudes due to a higher rainfall amounts. Salinity also varies at depth because and horizontal salinity gradients are often observed in the oceans (Bigg 2003). See Figure 2 for a generalized representation of salinity at various ocean depths.

Figure 2: Temperature and Salinity Profiles of the Ocean

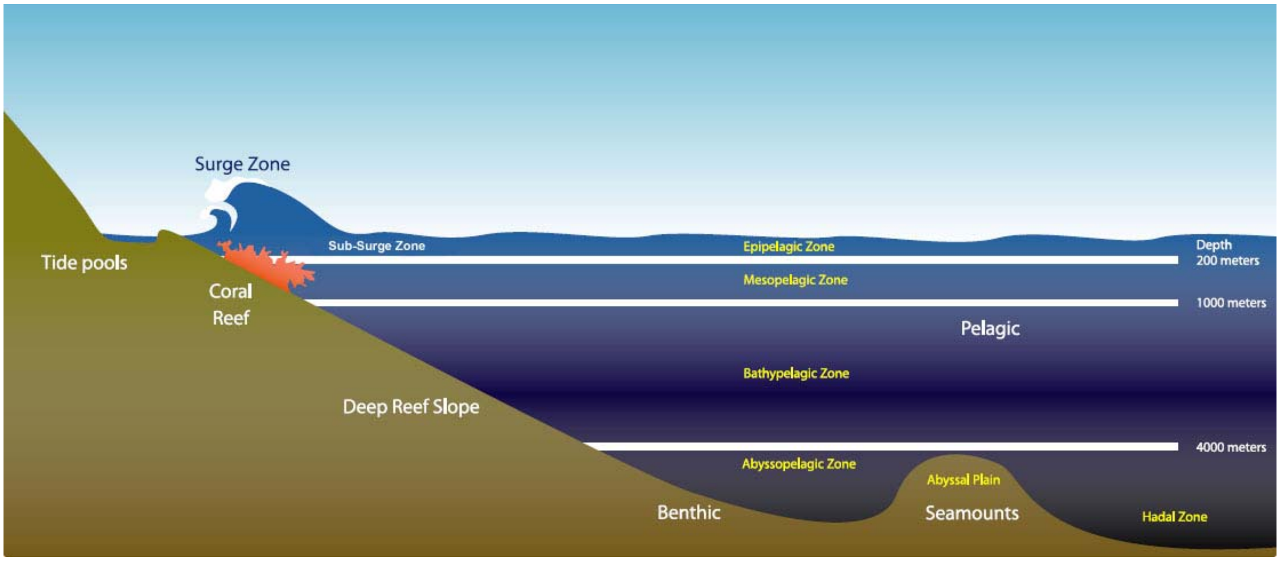


(Source: http://www.windows.ucar.edu/tour/link=/earth/Water/temp.html&edu=high)

3.1.5 Ocean Depth Zones

The ocean can separated into the following five zones (see Figure 3) relative to the amount of sun light that penetrates through sea water: a) epipelagic, b) mesopelagic, c) bathypelagic, d) abyssalpelagic, e) hadalpelagic. Sunlight is the principle factor of primary production (phytoplankton) in marine ecosystems, and since sun light diminishes with ocean depth, the amount of sunlight penetrating sea water and its affect on the occurrence and distribution of marine organisms is important. The epipelagic zone extends to nearly 200 m and is the near extent of visible light in the ocean. The mesopelagic zone occurs between 200 m and 1,000 m and is sometimes referred to as the twilight zone. Although the light that penetrates to the mesopelagic zone is extremely faint, this zone is home to wide variety of marine species. The bathypelagic zone occurs from 1,000 ft to 4,000 m and the only visible light seen is the product of marine organism producing their own light call bioluminescence. The next zone is the abyssalpelagic zone (4,000 m- 6,000 m), where there is extreme pressure and the water temperature is near freezing. This zone does not provide habitat for very many creatures except small invertebrates such as squid and basket stars. The last zone is called the hadalpelagic (6,000 m and below) and occurs in trenches and canyons. Surprisingly, marine life such as tube worms and starfish are found is this zone, often near hydrothermal vents.

Figure 3: Depth Profile of Ocean Zones (source: WPFMC 2005)



3.1.6 Ocean Water Circulation

The circulation of ocean water is a complex system involving the interaction between the oceans and atmosphere. The system is primarily driven by solar radiation which results in wind being produced from the heating and cooling of ocean water and the evaporation and precipitation of atmospheric water. Except for equatorial region, which receives a nearly constant amount of solar radiation, the latitude and seasons affect how much solar radiation is received in a particular region of the ocean. This in turn has an affect on sea-surface temperatures and the production of wind through the heating and cooling of the system (Tomzack and Godfrey 2003).

3.1.7 Surface Currents

Ocean currents can be thought of as organized flows of water which exist over a geographic scale and time period in which is water transported from one part of the ocean to another part of the ocean (Levington 1995). In addition to water, ocean currents also transport plankton, fish, heat, momentum, salts, oxygen, and carbon dioxide. Wind is the primary force which drives ocean surface currents, however the Earth's rotation and wind determines the direction of current flow. The sun and moon also influence ocean water movements by creating tidal flow, which is more readily observed in coastal areas rather than open ocean environments (Tomzack and Godfrey 2003). Figure 4 shows the major surface currents of the Pacific Ocean.

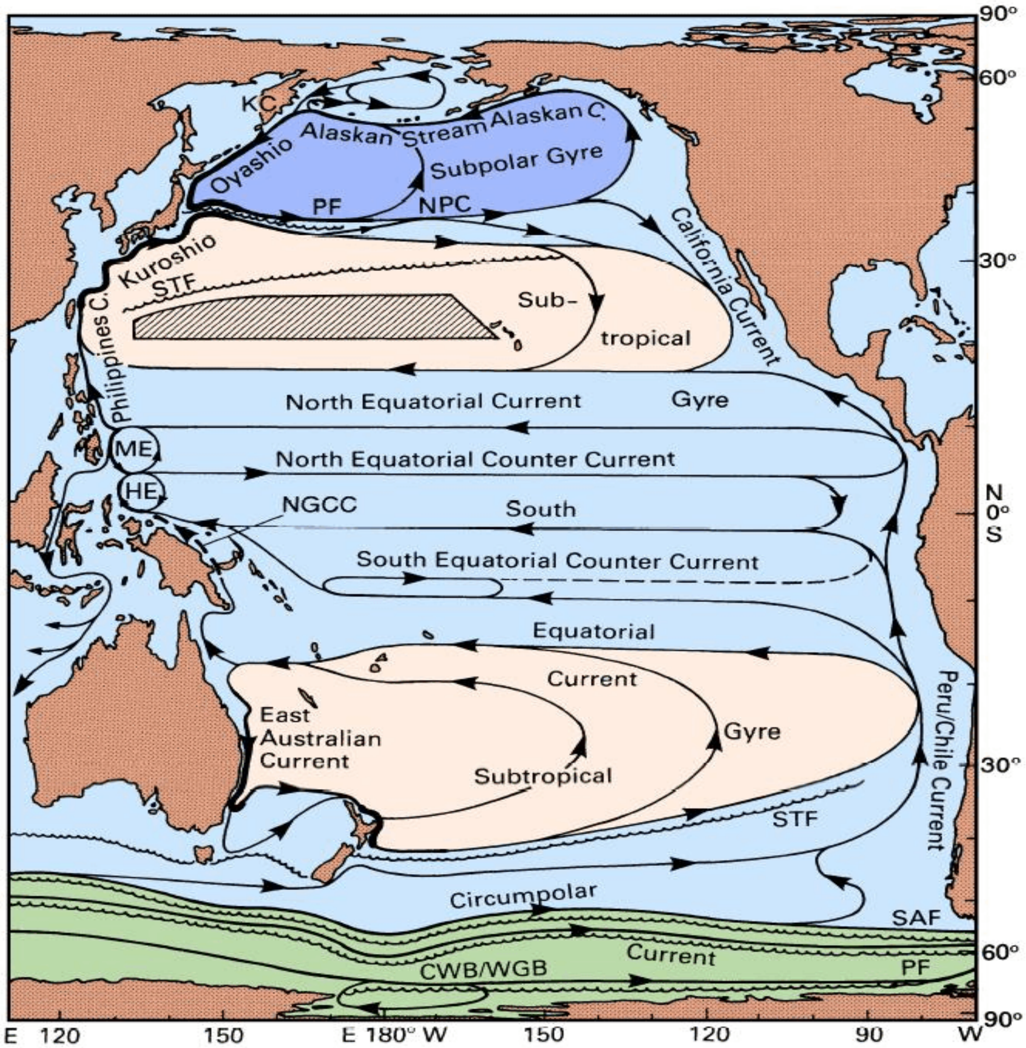
3.1.8 Transition Zones

Transition zones are areas of ocean water bounded to the north and south by large scale surface currents originating from subartic and subtropical locations (Polovina et al. 2001). Located generally between 32° N and 42° N, the North Pacific Transition Zone is an area between the southern boundary of the Subartic Frontal Zone (SAFZ) and the northern boundary of the Subtropical Frontal Zone (STFZ) (see Figure 5). Individual temperature and salinity gradients are observed within each front, but generally the SAFZ is colder (~ 8° C) and less salty (~ 33.0 ppm) than the STFZ (18° C, ~ 35.0 ppm, respectively). The North Pacific Transition Zone (NPTZ) supports a marine food chain that experiences variation in productivity in localized areas due to changes in nutrient levels brought on, for example, by storms or eddies. A common characteristic among some of the most abundant animals found in the Transition Zone such as flying squid, blue sharks, Pacific pomfret, and Pacific saury is that they undergo seasonal migrations from summer feeding grounds in subartic waters to winter spawning grounds in the subtropical waters. Other animals found in the NPTZ include swordfish, tuna, albatross, whales, and sea turtles (Polovina et al. 2001).

3.1.9 Eddies

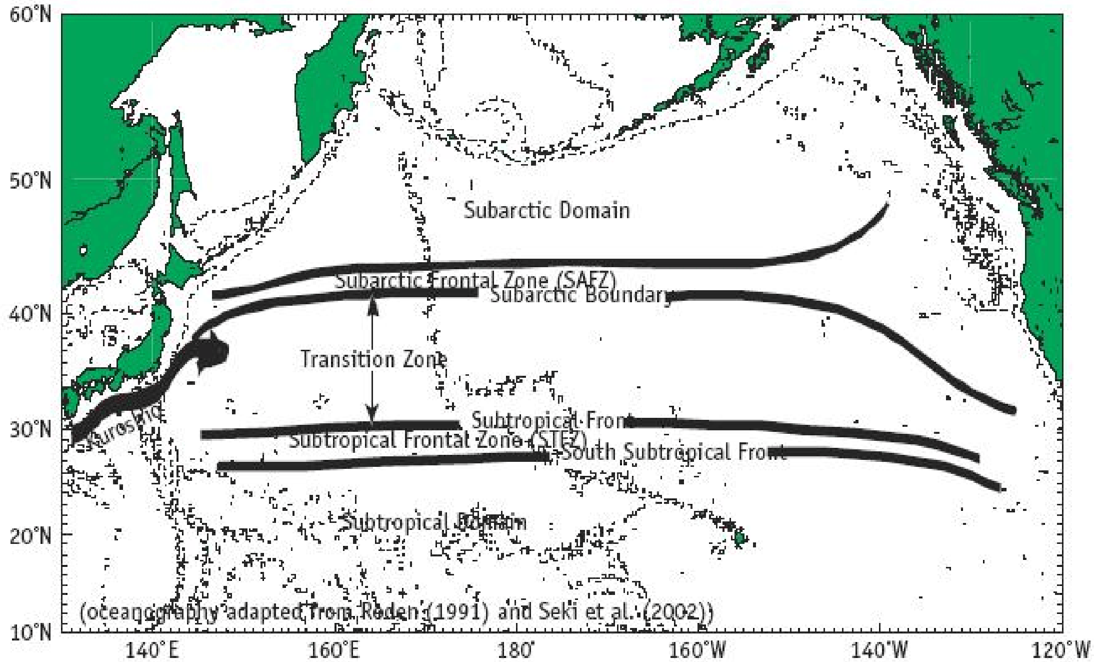
Eddies are generally short to medium term water movements which spin off of surface currents and can play important roles in regional climate (e.g. heat exchange) as well as the distribution of marine organisms. Large-scale eddies spun of the major surface currents often blend cold water with warm water, the nutrient-rich with the nutrient-poor, and the salt-laden with fresher waters (Bigg 2003). The edges of eddies, where the mixing is greatest, are often targeted by fishermen as these are areas of high biological productivity. In the Hawaiian Islands, the prevailing northeasterly trade winds combined with the topography of the area generate eddies on the leeward (western) side of the Islands. These eddies have been observed to last 50 to 70 days and are attributed to enhance upwelling of nutrients into euphotic zone and increased levels of primary productivity compared to non-eddy areas (Seki et al. 2001).

Figure 4: Major Surface Currents of the Pacific Ocean
(Source: Tomzack & Godfrey 2003)



Abbreviations are used for the Mindanao Eddy(ME), the Halmahera Eddy (HE), the New Guinea Coastal (NGCC), the North Pacific (NPC), and the Kamchatka Current (KC). Other abbreviations refer to fronts: NPC: North Pacific Current, STF: Subtropical Front, SAF: Subantarctic Front, PF: Polar Front, CWB/WGB: Continental Water Boundary / Weddell Gyre Boundary. The shaded region indicates banded structure (Subtropical Countercurrents). In the western South Pacific Ocean the currents are shown for April - November when the dominant winds are the Trades. During December - March the region is under the influence of the northwest monsoon, flow along the Australian coast north of 18°S and along New Guinea reverses, the Halmahera Eddy changes its sense of rotation and the South Equatorial Current joins the North Equatorial Countercurrent east of the eddy (Tomzack & Godfrey 2003).

Figure 5: North Pacific Transition Zone



(Source: http://www.pices.int/publications/special_publications/NPESR/2005/File_12_pp_201_210.pdf)

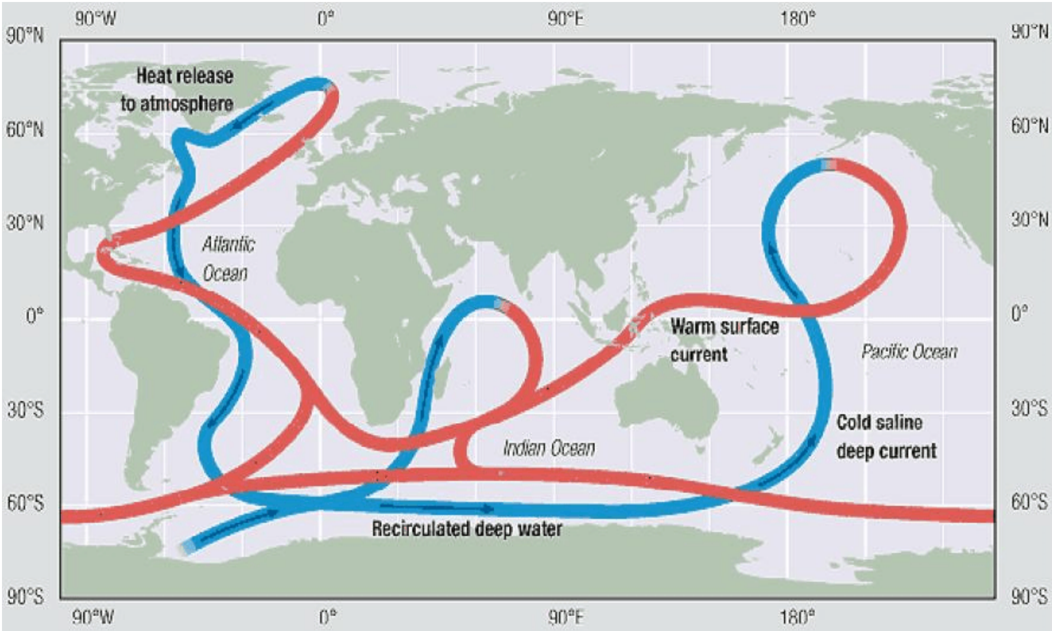
3.1.10 Deep Ocean Currents

As described in Tomzack and Godfrey (2003), deep ocean currents or thermohaline movements, result from effect of salinity and temperature on the density of sea water. In the Southern Ocean, for example, water exuded from sea ice is extremely dense due to its high salt content. The movement of the dense water is influence by bathymetry as the it sinks to the bottom and flows "down-slope" filling up the deep polar ocean basins. For example, the Arctic Ocean does not contribute much of its dense water to the Pacific Ocean due to the narrow shallows of the Bering Straight. Generally, the deep water currents flow through the Atlantic Basin, around South Africa, into the Indian Ocean, past Australia, and into the Pacific Ocean. This process has been labeled the "ocean conveyor belt"– taking nearly 1200 years to complete one cycle. The movement of the thermohaline conveyor is believed affect global weather patterns (Gelbspan 2004), and has been the subject of research as well as Hollywood.[5] See Figure 6 for a simplified schematic diagram of the deep ocean conveyor belt system.

Figure 6: Deep Ocean Water Movement

[5] "The Day After Tomorrow" (20th Century Fox- March 2004).

(Source: UN GEO Yearbook 2004)



3.1.1.1 Prominent Pacific Ocean Meteorological Features

The air-sea interface is a dynamic relationship in which the ocean and atmosphere exchange energy and matter. This relationship is the basic driver for the circulation of surface water (through wind stress) as well as for atmospheric circulation (through evaporation). The formation of weather systems and atmospheric pressure gradients are linked to exchange of energy (e.g. heat) and water between air and sea (Bigg 2003).

Near the equator, intense solar heating causes air to rise and water to evaporate resulting in areas of low pressure. Air flowing from higher "trade wind" pressure areas move to low pressure areas such as the Intertropical Convergence Zone (ITCZ) and the South Pacific Convergence Zone (SPCZ), which are located around 5°N and 30°S, respectively. Converging trade winds in these areas, do not produce high winds, but instead often form areas which lack significant wind speeds. These areas of low winds are known as the "doldrums." The convergence zones are associated near ridges of high sea surface temperatures, with temperatures of 28°C and above, and are areas of cloud accumulation and high rainfall amounts. The high rainfall amounts reduce ocean water salinity levels in these areas (Sturman and McGowan 2003).

The air that has risen in equatorial region fans out in to the higher troposphere layer of the atmosphere and settles back towards Earth at middle latitudes. As the air settles towards Earth it creates areas of high pressure known as subtropical high pressure belts. One of these high pressure areas in the Pacific is called the Hawaiian High Pressure Belt, which is responsible for the prevailing trade wind pattern observed in the Hawaiian Islands (Sturman and McGowan 2003).

The Aleutian Low Pressure System is another prominent weather feature in the Pacific Ocean and is caused by dense polar air converging with air from the subtropical high pressure belt. As these air masses converge around 60° N, air is uplifted creating in an area of low pressure. When the relatively warm surface currents (Figure 5) meet the colder air temperatures of sub-polar regions, latent heat is released causing precipitation. The Aleutian Low is an area where large storms with high winds are produced. Such large storms and wind speeds have the ability to affect the amount of mixing and upwelling between ocean layers (e.g. mixed layer and thermocline)(Polovina et al. 1994).

The dynamics of the air-sea interface do not produce steady states of atmospheric pressure gradients and ocean circulation. As discussed the previous sections, there are consistent weather patterns (e.g. ITCZ) and surface currents (e.g. NEC), however variability within the ocean-atmosphere system results in changes in winds, rainfall, currents, water column mixing and sea level heights which can have profound effects on regional climates as well as on the abundance and distribution of marine organisms.

One example of a shift in ocean-atmospheric conditions in the Pacific Ocean is El Nino Southern Oscillation (ENSO). ENSO is linked to climatic changes in normal prominent weather features of the Pacific and Indian Oceans, such as the location of the ITCZ. ENSO, which can occur every 2-10 years, results in the reduction of normal trade winds which reduces the intensity of the westward flowing equatorial surface current (Sturman and McGowan 2003). In turn, the eastward flowing countercurrent tends to dominate circulation, bringing warm, low-salinity, low-nutrient water to the eastern margins of the Pacific Ocean. As the easterly trade winds are reduced, the normal, nutrient-rich upwelling system does not occur, leaving warm surface water pooled in the eastern Pacific Ocean.

The impacts of ENSO events are strongest in the Pacific through disruption of the atmospheric circulation, generalized weather patterns and fisheries. ENSO affects the ecosystem dynamics in the equatorial and subtropical Pacific by considerable warming of the upper ocean layer, rising of the thermocline in the western Pacific and lowering in the east, strong variations in the intensity of ocean currents, low trade winds with frequent westerlies, high precipitation at the dateline and drought in the western Pacific (Sturman and McGowan 2003). ENSO events have the ability to significantly influence the abundance and distribution of organisms within marine ecosystems. Human communities also experience a wide range of socio-economic impacts from ENSO such changes in weather patterns resulting in catastrophic events (e.g. mud-slides in California due to high rainfall amounts) as well as linked to reductions in fisheries harvests (e.g. collapse of anchovy fishery off Peru and Chile)(Levington 1995, Polovina 2005).

Changes in the Aleutian Low Pressure System are another example of how interannual variation in a prominent Pacific Ocean weather feature profoundly effects on the abundance and distribution of marine organisms. Polovina et al. (1994) found that between 1977 and 1988 the intensification of the Aleutian Low Pressure System in the North Pacific resulted in a deeper mixed layer depth which lead to higher nutrients levels in the top layer of euphotic zone. This lead to an increase in phytoplankton production which resulted in higher productivity levels (higher abundance levels for some organisms) in the Northwestern Hawaiian Islands. Changes in the Aleutian Low Pressure System and its resulting effects on phytoplankton productivity have been observed on decadal scales (10 yrs) as well as for longer periods such as 20-30 years. The phenomenon is often referred to as Pacific Decadal Oscillation (Polovina et al. 1994, Polovina 2005).

3.1.1.2 Pacific Island Geography

The Pacific islands can be generally grouped into three major areas: 1) Micronesia, 2) Melanesia, and 3) Polynesia. However, the islands of Japan and the Aleutian Islands in the north Pacific are generally not included in these three areas, thus they are not included or described here as this analysis focuses on the Western Pacific Region and its ecosystems. Information used in this section was obtained from the online version of the U.S. Central Intelligence Agency's World Fact Book.[6]

3.1.1.2.1 Micronesia

Micronesia, which is primarily located in the western Pacific Ocean, is made up of hundreds of high and low islands within six archipelagos: a) Caroline Islands, b) Marshall Islands, c) Mariana Islands, d) Gilbert Islands, e) Line Islands, and f) Phoenix Islands.

The Caroline Islands (~ 850 sq miles) are composed of many low coral atolls, with a few high islands. Politically the Caroline Islands are separated into two countries: Palau and the Federated States of Micronesia.

The Marshall Islands (~180 sq miles) are made up of 34 low lying atolls separate between two chains; the southeastern Ratak Chain and the northwestern Ralik Chain.

The Mariana Islands (~ 396 sq miles) are composed of 15 volcanic islands which are part of a submerged mountain chain that stretch nearly 1,500 miles from Guam to Japan. Politically the Mariana Islands are split into the Territory of Guam and the Commonwealth of Northern Mariana Islands, of which both are U.S. possessions.

Nauru (~ 21 sq miles), located southeast of the Marshall Islands, is a raised coral reef atoll rich in phosphate. The island is governed by the Republic of Nauru, which is the smallest independent nation in the world.

The Gilbert Islands are located south of the Marshall Islands and are made up of 16 low-lying atolls.

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[6] http://www.cia.gov/cia/publications/factbook/index.html

The Phoenix Islands, located to the southwest of the Gilbert Islands, are composed of eight coral atolls. Howland and Baker Islands (U.S. possessions) are located within the Phoenix archipelago. The Line Islands, located in the central South Pacific, are made up of ten coral atolls, of which Kiribati, is the largest in the world (~ 609 sq miles). The U.S. possessions of Kingman Reef, Palmyra Atoll, and Jarvis Island are part the Line Islands. Except for the U.S. possessions, the rest of the islands and atolls in these three chains, however, are possessions of the Republic of Kiribati (~ 811 sq miles), which has an EEZ of nearly 1 million sq miles.

3.1.12.2 Melanesia

Melanesia is composed of several archipelagos which include: a) Fiji Islands, b) New Caledonia, c) Solomon Islands, d) New Guinea, e) Bismark Archipelago, f) Louisiade Islands, g) Tobriand Islands, h) Vanuatu Islands, i) Maluku Islands, and j) Torres Strait Islands.

Located approximately 3,500 miles northeast of Sydney, Australia, the Fiji Archipelago (~ 18,700 sq miles) is composed of nearly 800 islands, of which the largest are volcanic in origin and the smaller islands are coral atolls. The two largest islands, Viti Levu and Vanua Levu, comprise nearly 85 % of the Republic of Fiji Islands' total land area.

Located nearly 750 miles east-northeast of Australia, is the volcanic island of Grande Terre or New Caledonia (~ 6,300 sq miles). New Caledonia is French Territory and includes the nearby Loyalty Islands and the Chesterfield Islands, which are groups of small coral atolls.

The Solomon Islands (~ 27,500 sq miles) are located northwest of New Caledonia and east of Papua New Guinea. Thirty volcanic islands and several small coral atolls make up this former British colony which now a member of the Commonwealth of Nations. The Solomon Islands are made up of smaller groups of islands such as the New Georgia Islands, the Florida Islands, the Russell Islands, and the Santa Cruz Islands. Approximately 1,500 miles separates the western and eastern island groups of the Solomon Islands.

New Guinea is the world's second largest island and is thought to have separated from Australia around 5000 BC. New Guinea is split between two nations: Indonesia (west) and Papua New Guinea (east). Papua New Guinea (~ 178,700 sq miles) is an independent nation that also governs several hundred small islands within several groups. These groups include the Bismark Archipelago and the Louisiade Islands which are located north of New Guinea, and Tobriand Islands which are southeast of New Guinea. Most of the islands within the Bismark and Lousiade groups are volcanic in origin, whereas the Tobriand Islands are primarily coral atolls.

The Muluku Islands (east of New Guinea) and the Torres Strait Islands (between Australia and New Guniea) are also classified as part of Melanesia. Both of these island groups are volcanic in origin. The Muluku Islands are under by Indonesia's governance, while the Torres Strait Islands are governed by Australia.

The Vanuatu Islands (4,700 sq miles) comprise an archipelago that is located to the southeast of the Solomon Islands. There are 83 islands in the approximately 500 mile long Vanuatu chain, of which mostly all are volcanic in origin. Before becoming an independent nation in 1980 (Republic of Vanuatu), the Vanuatu Islands were colonies of both France and Great Britain and known as New Hebrides.

3.1.12.3 Polynesia

Polynesia is composed of several archipelagos and island groups including a) New Zealand and associated islands, b) Tonga, C) Samoa Islands, d) Tuvalu d) Tokelau, e) Cook Islands, f) Easter Island (Rapa Nui) and g) Hawaii.

New Zealand (~ 103,470 sq miles) is composed of two large islands, North Island and South Island and several small island groups and islands. North Island (~ 44, 035 sq miles) and South Island (~ 58, 200 sq miles) extend for nearly 1000 miles on northeast-southwest axis, and have a maximum width of 450 miles. The other small island groups within the former British colony include the Chatham Islands and the Kermadec Islands. The Chatham Islands are a group of ten volcanic islands located 800 km east of South Island. The four emergent islands of the Kermadec Islands are located 1000 km northeast North Island are part of a larger island arc with numerous subsurface volcanoes. The Kermadec Islands are known to be an active volcanic area where the Pacific Plate subducts under the Indo-Australian Plate.

The Tonga Islands (~ 290 sq miles) are located 450 miles east of Fiji and consist of 169 islands of volcanic and raised limestone origin. The largest island, Tongatapu (~ 260 sq miles), is home to two thirds of Tonga’s population (~106,000). The people of Tonga are governed under a hereditary constitutional monarchy.

The Samoa Archipelago is located northeast of Tonga and consists of seven major volcanic islands, several small islets, and two coral atolls. The largest islands in this chain are Upolu (~ 436 sq miles) and Savai`i (~ 660 sq miles). Upolu and Savai`i and its surrounding islets and small islands are governed by the Independent State of Samoa with a population of approximately 178,000 people. Tutuila (~ 55 sq miles), the Manua Islands (a group of four volcanic islands with a total land area of less than 20 sq miles), and two coral atolls, Rose Atoll and Swains Island, are governed by the U.S. Territory of American Samoa. Over 90 percent of American Samoa’s population (~ 68,000) live on Tutuila.

To the east of the Samoa Archipelago are the Cook Islands (~ 90 sq miles), which are separated into the Northern Group and Southern Group. The Northern Group consist of six sparsely populated coral atolls and the Southern Group consists of seven volcanic islands and two coral atolls. Rorotonga (~ 26 sq miles), located in the Southern Group, is the largest island in the Cook Islands and also serves as the capitol of this independent island nation. From north to south, the Cook Islands spread nearly 900 miles and the width between the most distant islands is nearly 450 miles. The Cook Island’s EEZ is approximately 850,000 sq miles.

Approximately 600 miles northwest of the Samoa Islands is Tuvalu (~ 10 sq miles), an independent nation made up of nine low-lying coral atolls. None of the islands have elevation higher than 14 feet and the total population of the country in around 11,000 people. Tuvalu's coral island chain extends for nearly 360 miles and the country has an EEZ 350,000 sq miles.

East of Tuvalu and north of Samoa are the Tokelau Islands (~ 4 sq miles). Three coral atolls comprise this territory of New Zealand, and a fourth atoll (Swains Island) is of the same group, but is controlled by the U.S Territory of American Samoa.

The 32 volcanic islands and 180 coral atolls of Territory of French Polynesia (~ 1,622 sq miles) are made up of the following six groups: Austral Islands, Bass Islands, Gambier Islands, Marquesas Islands, Society Islands, and the Tuamotu Islands. The Austral Islands are a group of six volcanic islands in the southern portion of the territory. The Bass Islands are a group of two islands in the southern most part of the territory with their volcanism appearing to be much more recent than that of the Austral Islands. The Gambier Islands are a small group of volcanic islands in southeastern portion of the Territory and often associated with the Tuamotu Islands because of their relative proximity, however, they are a distinct group because they are of volcanic origin rather than being coral atolls. The Tuamotu Islands, of which there are 78, are located in central portion of the Territory and are the world's largest chain of coral atolls. The Society Islands are group of several volcanic islands which include the island of Tahiti. The island of Tahiti is home to nearly 70 percent of French Polynesia's population of approximately 170,000 people. The Marquesa Islands are an isolated group of islands located in the northeast portion of the Territory; approximately 1,000 miles northeast of Tahiti. All but one of the 17 Marquesas Islands are volcanic in origin. French Polynesia has one of the largest EEZs in the Pacific Ocean at nearly 2 million square miles.

The Pitcairn Islands are a group of five islands thought to be an extension of the Tuamotu Archipelago. Pitcairn Island is the only volcanic island, with the others being coral atolls or uplifted limestone. Henderson Islands is the largest in the group, however, Pitcairn Island is the only one that is inhabited.

Easter Island, a volcanic high island located approximately 2,185 miles west of Chile, is thought to be the eastern extent of the Polynesian expansion. Easter Island, which is governed by Chile, has a total land area of 63 sq miles and population of approximately 3,790 people.

The northern extent of the Polynesian expansion is the Hawaiian Islands, which is made up of 137 islands, islets, and coral atolls. The exposed islands are part of a great undersea mountain range known as the Hawaiian-Emperor Seamount Chain which was formed by a hotspot within the Pacific Plate. The Hawaiian Islands extend for nearly 1,500 miles from Kure Atoll in the northwest to the Island of Hawaii in the southeast. The Hawaiian Islands are often grouped into the Northwestern Hawaiian Islands (Nihoa to Kure) and the Main Hawaiian Islands from (Hawaii to Niihau). The total land area of the 19 primary islands and atolls is approximately 6,423 sq miles and the over 75 percent of the 1.2 million population lives in on the island of Oahu.

3.2 Biological Environment

This section contains general descriptions of marine trophic levels, food chains and food webs, as well as a description of two general marine environments: benthic (associated with the sea floor) and pelagic (the water column and open ocean). A broad description of the types of marine organisms found within these environments is provided as well as a description of organisms important to fisheries. Protected species are also described in this section.

3.2.1 Marine Food Chains, Trophic Levels and Food Webs

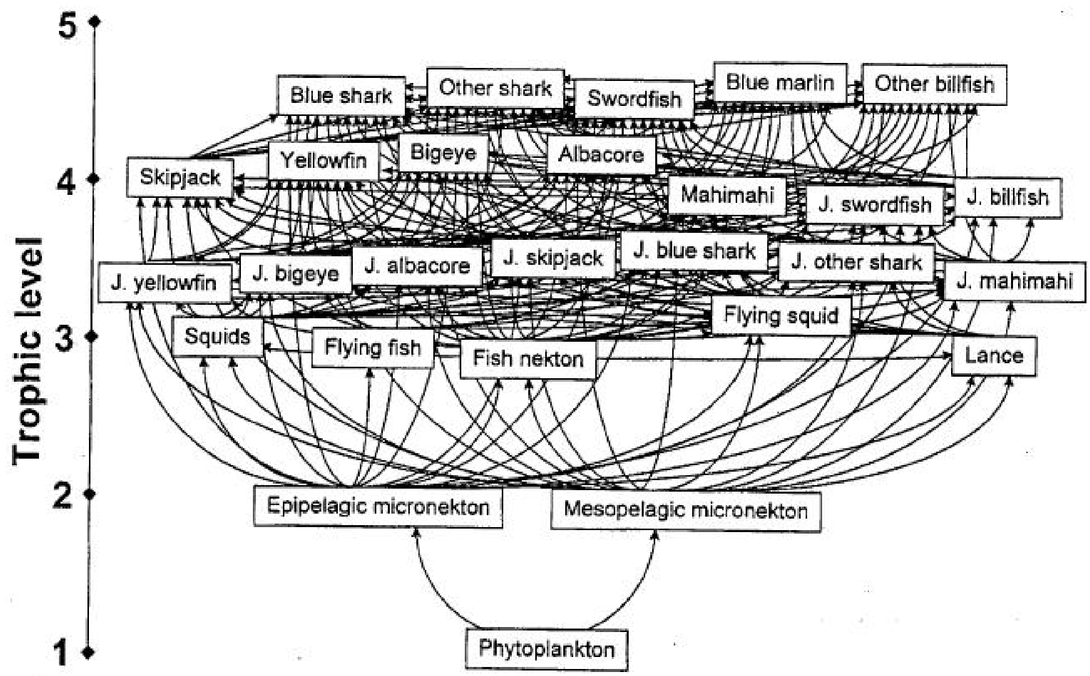
Food chains are often thought of as of linear representation of the basic flow of organic matter and energy through a series of organisms. Food chains in marine environments are generally segmented into the following six trophic levels: primary producers, primary consumers, secondary consumers, tertiary consumers, quaternary consumers, and decomposers.

Generally, primary producers in the marine ecosystems are organisms which fix inorganic carbon into organic carbon compounds using external sources of energy (i.e. sunlight). Such organisms include single-celled phytoplankton, bottom-dwelling algae, macroalgae (e.g. sea weeds), and vascular plants (e.g. kelp). All of these organisms share common cellular structures called chloroplasts, which contain chlorophyll. Chlorophyll is a pigment that absorbs the energy of light to drive the biochemical process of photosynthesis. Photosynthesis results in the transformation of inorganic carbon into organic carbon such as carbohydrates which are used for cellular growth.

Primary consumers in the marine environment are organisms which feed on primary producers and depending on the environment (i.e. pelagic vs. benthic) include zooplankton, corals, sponges, many fish, sea turtles, and other herbivorous organisms. Secondary, tertiary, and quaternary consumers in the marine environment are organisms which feed upon primary consumers and include fish, mollusks, crustaceans, mammals and other carnivorous and omnivorous organisms. Decomposers live off dead plants and animals and are essential in food chains to break down organic matter and make it available for primary producers (Valeila 2003).

Marine food webs are representations of overall patterns of feeding among organisms, but generally they are unable to capture the true complexity of the relationships between organisms and so they must be thought of simplified representations. An example of a marine food web is presented in Figure 7. The openness of marine ecosystems, lack of specialists, long lifespans, and large size changes and food preferences across the life histories of many marine species make marine food webs more complex than their terrestrial and freshwater counterparts (Link 2002). Nevertheless food webs are important tool in understanding ecological relationships amongst organisms.

Figure 7: Central Pacific Pelagic Food Web
(Source: Kitchell et al. 1999)



3.2.2 Benthic Environment

The word benthic comes from the Greek word *benthos* or "depths of the sea." The benthic or demersal environment is quite general in that it is regarded as extending from the hide tide mark to the deepest depths of the ocean floor. Benthic habitats are home to a wide range of marine organisms forming complex community structures. This section presents a simple description of the following benthic zones: a) intertidal, b) subtidal (e.g. coral reefs), c) banks and seamounts, d) deep-reef slope, e) deep ocean bottom (see Figure 3).

3.2.2.1 Intertidal Zone

The intertidal zone is relatively small margin of seabed that exists between the highest and lowest extent of the tides. Due to wave action on unprotected coastlines, the intertidal zone can sometimes extend beyond tidal limits due the splashing effect of waves. Vertical zonation amongst organisms are often observed in intertidal zones, where the lower limits of some organisms are determined by the presence of predators or competing species, whereas the upper limit is often controlled by physiological limits and species tolerance to temperature and drying (Levington 1995). Organisms which inhabit the intertidal zone include algae, seaweeds, mollusks, crustaceans, worms, echinoderms (starfish), and cnidarians (e.g. anemones).

Many organisms in the intertidal zone have adapted strategies to combat the effects of temperature, salinity, and desiccation due the wide ranging tides of various locations. Marine algae are the primary produces in most intertidal areas. Many species primary consumers such as snails graze on algae growing on rocky substrates in the intertidal zone. Secondary and tertiary consumers in intertidal zones include starfish, anemones, and seabirds. Due to the proximity of the intertidal zone to the shoreline, intertidal organisms are important food items to many human communities. In Hawaii, for example, intertidal limpet species (snails) such as `opihi *(Cellana exarata)* were eaten by early Hawaiian communities and are still a popular food item in Hawaii today. In addition to mollusks, intertidal seaweeds are also important food items for Pacific islanders.

3.2.2.2 Seagrass Beds

Seagrasses are found in many marine ecosystems and are a regular feature of many inshore areas adjacent to coral reefs in the Pacific. According to Hatcher et al. (1989), seagrasses stabilize sediments because leaves slow current flow, thus increasing sedimentation of particles. The roots and rhizomes form a complex matrix that binds sediments and stops erosion. Seagrass beds provide habitat for certain commercially valuable shrimps as well as habitat for reef-associated species such as surgeonfishes (*Acanthuridae*) and rabbitfishes (*Siganidae*). Seagrasses are also important sources of nutrition for higher vertebrates such as dugongs and green sea turtles. A concise summary of the seagrass species found in the western tropical South Pacific is given by Coles and Kuo (1995). From the fisheries perspective, the fishes and other organisms harvested from the reef coral and associated habitats such as mangroves, seagrass beds, shallow lagoons, bays, inlets and harbors, and the reef slope beyond the limit of coral reef growth, contribute to the total yield from coral reef-associated fisheries.

3.2.2.3 Mangrove Forests

Mangroves are terrestrial shrubs and trees which are able to live the salty environment of the intertidal zone. Their prop roots form important substrate on which sessile organisms can grow as well as provided shelter for fishes. Mangroves are believed to provide important nursery habitat for many juvenile reef fishes. The natural eastern limit of mangroves in the Pacific is American Samoa, although the red mangrove (*Rhizophora mangle*), was introduced into Hawaii in 1902, and has become the dominant plant within a number of large protected bays and coastlines on both Oahu and Molokai (Gulko 1998). Apart from the usefulness of the wood for building, charcoal, and tannin, mangrove forests stabilize areas where sedimentation is occurring and are important as nursery grounds for peneaeid shrimps and some inshore fish species, and form the habitat for some commercially valuable crustaceans.

3.2.2.4 Coral Reefs

Coral reefs are carbonate rock structures at or near sea level that support viable populations of scleractinian or reef-building corals. Apart from a few exceptions in the Pacific Ocean, coral reefs are confined to the warm tropical and sub-tropical waters lying between 30° N and 30° S. Coral reef ecosystems are some of the most diverse and complex ecosystems on earth. Their complexity is manifest on all conceptual dimensions, including geological history, growth and structure, biological adaptation, evolution and biogeography, community structure, organism and ecosystem metabolism, physical regimes, and anthropogenic interactions (Hatcher et al. 1989).

Coral reefs and reef-building organisms are confined to the shallow upper euphotic zone. Maximum reef growth and productivity occurs between 5-15 m (Hopley and Kinsey 1988) and maximum diversity of reef species occurs at 10-30 m (Huston 1985). Thirty meters has been described as a critical depth below which rates of growth (accretion) of coral reefs are often too slow to keep up with changes in sea level. This was true during the Holocene transgression over the last 10,000 years, and many reefs below this depth drowned during this period. Coral reef habitat does extend deeper than 30 m, but few well developed reefs are found below 50 m. Many coral reefs are bordered by broad areas of shelf habitat (reef slope) between 50-100 m which were formed by wave erosion during periods of lower sea level during. These reef slope habitats consist primarily of carbonate rubble, algae and micro-invertebrate communities, some of which may be important nursery grounds for some coral reef fish, as well as habitat for several species of lobster. However, the ecology of this habitat is poorly known and much more research is needed to define the lower depth limits of coral reefs, which by inclusion of shelf habitat, could be viewed as extending to 100 m.

The symbiotic relationship between the animal coral polyps and algal cells (dinoflagellates) known as zooxanthellae is a key feature of reef building corals. Incorporated into the coral tissue, these photosynthesizing zooxanthellae provide much of the polyp's nutritional needs, primarily in the form of carbohydrates. Most corals supplement this food source by actively feeding on zooplankton or dissolved organic nitrogen, because of the low nitrogen content of the carbohydrates derived from photosynthesis. Due to reef building coral's symbiotic relationship with photosynthetic zooxanthellae, reef building corals do not generally occur at depths greater than 100 m (300 ft) (Hunter 1995).

Primary production on coral reefs is associated phytoplankton, algae, sea grasses, and zooxanthellae. Primary consumers included many different species of corals, mollusks, crustaceans, echinoderms, gastropods, sea turtles, and fish (e.g. parrot fish). Secondary consumers include anemones, urchins, crustaceans, and fish. Tertiary consumers include eels, octopus, barracudas, and sharks.

The corals and coral reefs of the Pacific are described in Wells and Jenkins (1988) and Veron (1995). The number of coral species declines in an easterly direction across the western and central Pacific in common with the distribution of fish and invertebrate species. Over 330 species are contained in 70 genera on the Australian Barrier Reef, compared with only 30 coral genera present in the Society Islands of French Polynesia, and 10 genera in the Marquesas and Pitcairn Islands. Hawaii, by virtue of its isolated position in the Pacific, also has relatively few species of coral (about 50 species in 17 genera) and, more importantly, lacks most of the branching or "tabletop" *Acropora* species that form the majority of reefs elsewhere in the Pacific. The

Acropora species provide a large amount of complex three-dimensional structure and protected habitat for a wide variety of fishes and invertebrates. As a consequence, Hawaiian coral reefs provide limited 'protecting' three-dimensional space. This is thought to account for the exceptionally high rate of endemism among Hawaiian marine species. Further, many believe that this is the reason certain fish and invertebrate species look and act very differently from similar members of the same species found in other parts of the South Pacific (Gulko 1998).

Coral Reef Productivity

Coral reefs are among the most biologically productive environments in the world. The global potential for coral reef fisheries has been estimated at nine million metric tons per year, which is impressive given the small area of reefs compared to the extent of other marine ecosystems, which collectively produce between 70 - 100 million metric tons per year (Munro 1984; Smith 1978). An apparent paradox of coral reefs, however, are their location in the low-nutrient areas of the tropical oceans. Coral reefs themselves are characterized by the highest gross primary production in the sea, with sand, rubble fields, reef flats and margins adding to primary production rates. The main primary producers on coral reefs are the benthic microalgae, macroalgae, symbiotic microalgae of corals, and other symbiont-bearing invertebrates (Levington 1995). Zooxanthellae living in the tissues of hard corals make a substantial contribution to primary productivity in zones rich in corals due to their density—greater than 10^6 cells cm^{-2} of live coral surface—and the high rugosity of the surfaces on which they live, as well as their own photosynthetic potential. However, zones of high coral cover make up only a small part of entire coral reef ecosystems, and so their contribution to total coral reef primary productivity is small (WPFMC 2001).

Although the ocean's surface waters in the tropics generally have low productivity, these waters are continually moving. Coral reefs therefore have access to open-water productivity and thus, particularly in inshore continental waters, shallow benthic habitats such as reefs are not always the dominant sources of nutrients for fisheries. In coastal waters detrital matter from land, plankton, and fringing marine plant communities are particularly abundant. There may be passive advection of particulate and dissolved detrital carbon onto reefs, and active transport onto reefs via fishes that shelter on reefs but feed in adjacent habitats. here is, therefore, greater potential for nourishment of inshore reefs than offshore reefs by external sources, and this inshore nourishment is enhanced by large land masses (Birkeland 1997).

For most of the Pacific Islands, rainfall typically ranges from 20 to 35 m per year. Low islands, such as atolls, tend to have less rainfall and may suffer prolonged droughts. Further, when rain does fall on coral islands that have no major catchment area, there is little nutrient input into surrounding coastal waters and lagoons. Lagoons and embayments around high islands in the South Pacific are therefore likely to be more productive than atoll lagoons. There are however, some exceptions such as Palmyra Atoll and Rose Atoll which receive up to 43 m of rain per year. The productivity of high island coastal waters, particularly where there are lagoons and sheltered waters, is possibly reflected in the greater abundance of small pelagic fishes such as anchovies, sprats, sardines, scads, mackerels, and fusiliers. In addition, the range of different environments that can be found in the immediate vicinity of the coasts of high islands also contribute to the greater range of biodiversity found in such locations.

Coral Reef Communities

A major portion of the primary production of the coral reef ecosystem comes from complex inter-kingdom relationships of animal/plant photo-symbioses hosted by animals of many taxa, most notably stony corals. Most of the geological structure of reefs and habitat is produced by these complex symbiotic relationships. Complex symbiotic relationships for defense from predation, removal of parasites, building of domiciles, and other functions are also prevalent. About 32 of the 33 animal phyla are represented on coral reefs (only 17 are represented in terrestrial environments) and this diversity produces complex patterns of competition. The diversity also produces a disproportionate representation of predators, which have strong influences on lower levels of the food web in the coral reef ecosystem (Birkeland 1997).

In areas with high gross primary production—such as rain forests and coral reefs—animals and plants tend to have a higher variety and concentration of natural chemicals as defenses against herbivores, carnivores, competitors, and microbes. Because of this tendency, and the greater number of phyla in the system, coral reefs are now a major focus for bioprospecting, especially in the southwest tropical Pacific (Birkeland 1997).

Typically, spawning of coral reef fish occur in the vicinity of the reef and is characterized by frequent repetition throughout a protracted time of the year, a diverse array of behavioral patterns, and extremely high fecundity. Coral reef species exhibit a wide range of strategies related larval dispersal and ultimately recruitment into the same or new areas. Some larvae are dispersed as short lived, yolk dependent (lecithotrophic) organisms, but the majority of coral reef invertebrate species disperse their larvae (planktotrophic) into the pelagic environment to feed on various types of plankton (Levington 1995). For example, larvae of the coral *Pocillopora damicornis*, which is widespread throughout the Pacific, has been found in the plankton of the open ocean exhibiting a larval life span of over 100 days (Levington 1995). Because many coral reefs being space limited for settlement, planktotrophic larvae is a likely a strategy to increase survival in other areas (Levington 1995). Coral reef fish experience their highest predation mortality in their first few days or weeks, thus rapid growth out of the juvenile stage is a common strategy.

The condition of the overall populations of particular species is linked to the variability among sub-populations: the ratio of sources and sinks, their degrees of recruitment connection, and the proportion of the sub-populations with high variability in reproductive capacity. Recruitment to populations of coral reef organisms depends largely on the pathways of larval dispersal and “downstream” links.

Reproduction and Recruitment

The majority of coral reef associated species are very fecund, but temporal variations in recruitment success have been recorded for some species and locations. Many of the large, commercially-targeted coral reef species are long-lived and reproduce for a number of years. This is in contrast to the majority of commercially-targeted species in the tropical pelagic ecosystem. Long-lived species adapted to coral reef systems are often characterized by complex reproductive patterns like sequential hermaphroditism, sexual maturity delayed by social hierarchy, multi-species mass spawnings, and spawning aggregations in predictable locations (Birkeland 1997).

Growth and Mortality Rates

Recruitment of coral reef species is limited by high mortality of eggs and larvae, and also by competition for space to settle out on coral reefs. Predation intensity is due to a disproportionate number of predators, which limits juvenile survival (Birkeland 1997). In response some fishes—such as scarids (parrotfish) and labrids (wrasses)—grow rapidly compared with other coral reef fishes. But they still grow relatively slowly compared to pelagic species. In addition, scarids and labrids may have complex haremic territorial social structures that contribute to the overall effect of harvesting these resources. It appears that many tropical reef fishes grow rapidly to near-adult size, and then often grow relatively little over a protracted adult life span; they are thus relatively long-lived. In some groups of fishes, such as damselfish, individuals of the species are capable of rapid growth to adult size, but sexual maturity is still delayed by social pressure. This complex relationship between size and maturity makes resource management more difficult (Birkeland 1997).

Community Variability

High temporal and spatial variability is characteristic of reef communities. At large spatial scales, variation in species assemblages may be due to major differences in habitat types or biotopes. Seagrass beds, reef flats, lagoonal patch reefs, reef crests, and seaward reef slopes may occur in relatively close proximity, but represent notably different habitats. For example, reef fish communities from the geographically isolated Hawaiian Islands are characterized by low species richness, high endemism, and exposure to large semiannual current gyres, which may help retain planktonic larvae. The NWHI is further characterized by: (1) high latitude coral atolls; (2) a mild temperate to subtropical climate, where inshore water temperatures can drop below 18° C in late winter; (3) species that are common on shallow reefs and attain large sizes, which to the southeast occur only rarely or in deep water; and 4) inshore shallow reefs that are largely free of fishing pressure (Maragos and Gulko 2002).

3.2.2.5 Deep Reef Slopes

As most Pacific islands are oceanic islands vs. continental islands, they generally lack an extensive shelf area of relatively shallow water extending beyond the shoreline. For example, the average global continental shelf extends 40 miles with a depth of around 200 ft (Postma and Zijlstra 1988). While lacking a shelf, many oceanic islands have a deep reef slope which is often angled between 45 and 90 degrees towards the ocean floor. The deep reef slope is home to a wide variety marine of organisms which are important fisheries target species such as snappers and groupers. Biological zonation does occur on the reef slope, and is related to the limit of light penetration beyond 100 m. For example, reef-building corals can be observed at depths less than 100 m, but at greater depths gorgonian and anthozoan corals are more readily observed (Colin 1986).

3.2.2.6 Banks and Seamounts

Banks are generally volcanic structures of various sizes and occur both on the continental shelf and in oceanic waters. Coralline structures tend to be associated with shallower parts of the banks as reef building corals are generally restricted to a maximum depth of 100 m. Deeper parts of banks may be composed of rock or coral rubble, sand or shell deposits. Banks thus support a variety of habitats, that in turn support a variety of fish species (Levington 1995).

Fish distribution on banks is affected by substrate types and composition. Those suitable for lutjanids, serranids and lethrinids tend to be patchy, leading to isolated groups of fish with little lateral exchange or adult migration except when patches are close together. These types of assemblages may be regarded as consisting of meta-populations that are associated with specific features or habitats, interconnected through larval dispersal. From a genetic perspective, individual patch assemblages may be considered as the same population, however, in many locations not enough is known about exchange rates to distinguish discrete populations.

Seamounts are undersea mountains, mostly of volcanic origin, which rise steeply from the sea bottom to just below sea level (Rogers 1994). On seamounts and surrounding banks, species composition is closely related to depth. Deep slope fisheries typically occur in the 100-500 m depth range. A rapid decrease in species richness typically occurs between 200-400 m depth, and most fish observed are associated with hard substrates, holes, ledges or caves (Chave and Mundy 1994). Territoriality is considered to be less important for deep water species of serranids, and lutjanids tend to form loose aggregations. Adult deep water species are believed to not normally migrate between isolated seamounts.

Seamounts have complex effects on ocean circulation. One effect, known as the Taylor column, relates to eddies trapped over seamounts to form quasi-closed circulations. It is hypothesized that this helps retain pelagic larvae around seamounts and maintain the local fish population. Although evidence for retention of larvae over seamounts is sparse (Boehlert and Mundy 1993), endemism has been reported for a number of fish and invertebrate species at seamounts (Rogers 1994). Wilson and Kaufman (1987) concluded that seamount species were dominated by those on nearby shelf areas, and that seamounts can act as stepping stones for trans-oceanic dispersal. Snappers and groupers both produce pelagic eggs and larvae which tend to be most abundant over deep reef slope waters, while larvae of Etelis snappers, are generally found in oceanic waters. It appears that populations of snappers and groupers on seamounts rely on inputs of larvae from external sources.

3.2.2.7 Deep Ocean Floor

At the end of reef slope lies the dark and cold world of the deep ocean floor. Composed of mostly mud and sand, the deep ocean floor is home to deposit feeders, suspension feeders, as well as fish and marine mammals. Compared to shallower benthic areas (e.g. coral reefs), benthic deep slope areas are lower in productivity and biomass. Due to the lack of sunlight, primary productivity is low, and many organisms rely on deposition of organic matter which sinks to the bottom. The occurrence of secondary and tertiary consumers decrease the deeper one goes due to the lack of available prey. Also with increasing depth, suspension feeders become less abundant and deposit feeders become the dominant feeding type (Levington 1995).

Although most of the deep sea bed is homogenous and low in productivity, there are hot spots teaming life. In areas of volcanic activity such as the mid-oceanic ridge, there exists thermal vents which spew hot water loaded with various metals and dissolved sulfide. Bacteria found in these areas are able to make energy from the sulfide, thus considered primary producers, in which a variety of organisms either feed on or contain in their bodies within special organs called trophosomes. Types of organisms found near these thermal vents include crabs, limpets, tubeworms, and bivalves (Levington 1995).

3.2.2.8 Benthic Species of Economic Importance

The following sub-sections of 3.2.2.8 provide descriptions of species harvested in noteworthy numbers in the Western Pacific Region.

3.2.3.8.1 Coral Reef Associated Species

The most commonly harvested species of coral reef associated organisms include: surgeonfishes (*Acanthuridae*), triggerfishes (*Balistidae*), jacks (*Carangidae*), soldierfish/squirrelfish (*Holocentridae*), wrasses (*Labridae),* parrotfishes (*Scaridae*), octopus (*Octupus cyanea, O. ornatus*) and goatfishes (*Mullidae*). Studies on coral reef fisheries are relatively recent, commencing with the major study by Munro and his co-workers during the late 1960s in the Caribbean (Munro 1983). Even today, only a relatively few examples are available of in-depth studies on reef fisheries.

It was initially thought that the maximum sustainable yields for coral reef fisheries were in the range of 0.5-5 $t/km^{-2}yr^{-1}$, based on limited data (Marten and Polovina 1982; Stevenson and Marshall 1974). Much higher yields of around 20 $t/km^{-2}yr^{-1}$, for reefs in the Philippines (Alcala 1981; Alcala and Luchavez 1981) and American Samoa (Wass 1982), were thought to be unrepresentative (Marshall 1980), but high yields of this order have now been independently estimated for a number of sites in the South Pacific and Southeast Asia (Dalzell and Adams 1997; Dalzell et al. 1996). These higher estimates are closer to the maximum levels of fish production predicted by trophic and other models of ecosystems (Polunin and Roberts 1996). Dalzell and Adams (1997) suggest that the average MSY for Pacific reefs is in the region of 16 $t/km^{-2}yr^{-1}$ based on 43 yield estimates where the proxy for fishing effort was population density.

However, Birkeland (1997) has expressed some skepticism about the sustainability of the high yields reported for Pacific and Southeast Asian reefs. Among other examples, he notes that the high values for American Samoa reported by Wass (1982) during the early 1970's were followed by a 70% drop in coral reef fishery catch rates between 1979 and 1994. Saucerman (1995) ascribed much of this decline to a series of catastrophic events over the same period. This began with a crown of thorns infestation in 1978, followed by hurricanes in 1990 and 1991, which reduced the reefs to rubble, and a coral bleaching event in 1994, probably associated with the El Niño phenomenon. These various factors reduced live coral cover in American Samoa from a mean of 60% in 1979, to between 3-13% in 1993 (Saucerman 1995).

Further, problems still remain in rigorously quantifying the effects of factors on yield estimates, such as primary productivity, depth, sampling area, or coral cover. Polunin et al. (1996) noted that there was an inverse correlation between estimated reef fishery yield and the size of the reef area surveyed, based on a number of studies reported by Dalzell (1996). Arias-Gonzales et al. (1994) have also examined this feature of reef fisheries yield estimates and noted that this was a problem when comparing reef fishery yields. The study noted that estimated yields are based on the investigator's perception of the maximum depth at which true reef fishes occur. Small pelagic fishes, such as scads and fusiliers, may make up large fractions of the inshore catch from a particular reef and lagoon system, and if included in the total catch can greatly inflate the yield estimate. The great variation in reef yield summarized by authors such as Arias-Gonzales et al. (1994), Dalzell (1996) and Dalzell and Adams (1997) may also be due in part to the different size and trophic levels included in catches.

Another important aspect of the yield question is the resilience of reefs to fishing and recovery potential when overfishing or high levels of fishing effort have been conducted on coral reefs. Evidence from a Pacific atoll where reefs are regularly fished by community fishing methods, such as leaf sweeps and spearfishing, indicated that depleted biomass levels may recover to pre-exploitation levels within one to two years. In the Philippines, abundances of several reef fishes have increased in small reserves within a few years of their establishment (Russ and Alcala 1994; White 1988), although recovery in numbers of fish is much faster than recovery of biomass, especially in larger species such as groupers. Other studies in the Caribbean and Southeast Asia (Polunin et al. 1996) indicate that reef fish populations in relatively small areas have the potential to recover rapidly from depletion in the absence of further fishing.

Estimating the recovery from, and reversibility of, fishing effects over large reef areas appears more difficult to determine. Where growth overfishing predominates, recovery following effort reduction may be rapid if the fish in question are fast growing, as in the case of goatfish (Garcia and Demetropolous 1986). However, recovery may be slower if biomass reduction was due to recruitment overfishing because it takes time to rebuild adult spawning biomasses and high fecundities (Polunin and Morton 1992). Further, many coral reef species have limited distributions; they may be confined to a single island or a cluster of proximate islands. Widespread heavy fishing could cause global extinctions of some such species, particularly if there is also associated habitat damage.

<u>Crustaceans</u>

Crustaceans are harvested on small scales throughout the inhabited islands of the Western Pacific Region. The most common crustaceans harvests include lobster species of the taxonomic groups *Palinuridae* (spiny lobsters) and *Scyllaridae* (slipper lobsters). Adult spiny lobsters are typically found on rocky substrate in well protected areas, in crevices and under rocks. Unlike many other species of *Panulirus*, the juveniles and adults of *P. marginatus* are not found in separate habitat apart from one another (MacDonald and Stimson 1980, Parrish and Polovina 1994). Juvenile *P. marginatus* recruit directly to adult habitat; they do not utilize separate shallow water nursery habitat apart from the adults as do many *Palinurid* lobsters (MacDonald and Stimson 1980, Parrish and Polovina 1994). Juvenile and adult *P. marginatus* do not utilize shelter differently from one another (MacDonald and Stimson 1980). Similarly, juvenile and adult *P. pencillatus* also share the same habitat (Pitcher 1993).

Pitcher (1993) observes that, in the southwestern Pacific, spiny lobsters are typically found in association with coral reefs. Coral reefs provide shelter as well as a diverse and abundant supply of food items, he notes. Pitcher also states that in this region, *P. pencillatus* inhabits the rocky shelters in the windward surf zones of oceanic reefs, an observation also noted by Kanciruk (1980). Other species of *Panulirus* show more general patterns of habitat utilization. At night, *P. penicillatus* moves on to reef flat to forage.

Spiny lobsters are non-clawed, decapod crustaceans with slender walking legs of roughly equal size. Spiny lobster have a large spiny carapace with two horns and antennae projecting forward of their eyes and a large abdomen terminating in a flexible tailfan (Uchida et al.1980). The appearance of the slipper lobster is notably different than that of the spiny lobster.

Uchida and Uchiyama (1986) provide a detailed description of the morphology of slipper lobsters (*S. squammosus* and *S. haanii)* and note that the two species are very similar in appearance and are easily confused (Uchida and Uchiyama 1986).

Spiny lobsters (*Panulirus* sp.) are dioecious (Uchida and Uchida 1986). Generally, the different species of the genus *Panulirus* have the same reproductive behavior and life cycle (Pitcher 1993). The male spiny lobster deposits a spermatophore or sperm packet on the female's abdomen (WPRFMC 1983). In *Panulirus* sp., the fertilization of the eggs occurs externally (Uchida et al. 1980). The female lobster scratches and breaks the mass, releasing the spermatozoa (WPRFMC 1983). Simultaneously, ova are released for the female's oviduct and are then fertilized and attach to the setae of the female's pleopod (WPRFMC 1983, Pitcher 1993). At this point the female lobster is ovigerous, or "berried" (WPRFMC 1983). The fertilized eggs hatch into phyllosoma larvae after 30–40 days (MacDonald 1986, Uchida 1986). Spiny lobsters are very fecund (WPRFMC 1983). The release of the phyllosoma larvae appears to be timed to coincide with the full moon and dawn in some species (Pitcher 1993). In *Scyllarides* sp. fertilization is internal (Uchida and Uchiyama 1986).

Very little is known about the planktonic phase of the phyllosoma larvae of *Panulirus marginatus* (Uchida et al. 1980). After hatching, the "leaf-like" larvae (or phyllosoma) enter a planktonic phase (WPRFMC 1983). The duration of this planktonic phase varies depending on the species and geographic region (WPRFMC 1983). The planktonic larval stage may last from 6 months to 1 year from the time of the hatching of the eggs (WPRFMC 1983, MacDonald 1986).

Johnston (1968) suggests that fine-scale oceanographic features, such as eddies and currents, serve to retain lobster larva within island areas. In the NWHI, for example, lobster larvae settlement appears to be linked to the north and southward shifts of the North Pacific Central Water type (MacDonald 1986). The relatively long pelagic larval phase for palinurids results in very wide dispersal of spiny lobster larvae; palinurid larvae can be transported up to 2,000 miles by prevailing ocean currents (MacDonald 1986).

3.2.3.8.2 Reef Slope, Bank, and Seamount Species

Bottomfish

The families of bottomfish and seamount fish which are often targeted include snappers (*Lutjanidae)*, groupers (*Serranidae*), jacks (*Carangidae*), and emperors (*Lethrinidae*). See section 2.2 for a complete list of Western Pacific Management Unit Species. Distinct depth associations are reported for certain species of emperors, snappers and groupers and many snappers, and some groupers are restricted to feeding in deep water (Parrish 1987). The emperor family *(Lethrinidae*) are bottom feeding carnivorous fish found usually in shallow coastal waters on or near reefs, with some species observed at greater depths (e.g., *L. rubrioperculatus*). Lethrinids are not reported to be territorial, but may be solitary or form schools. The snapper family (*Lutjanidae*) are largely confined to continental shelves and slopes, as well as corresponding depths around islands. Adults are usually associated with the bottom. The genus *Lutjanus* is the largest of this family consisting primarily of inhabitants of shallow reefs. Species of the genus *Pristipomoides* occur at intermediate depths, often schooling around rocky outcrops and promontories (Ralston et al. 1986) while *Eteline* snappers are deep water species. Groupers (*Serranidae*) are relatively larger and mostly occur in shallow areas, although some occupy deep slope habitats. Groupers in general are more sedentary and territorial than snappers or emperors and are more dependant on hard substrata. In general, groupers may be less dependant upon hard bottom substrates at depth (Parrish 1987). For each family, schooling behavior is reported more frequently for juveniles than adults. Spawning aggregations may, however, occur even for the solitary species at certain times of the year, especially among groupers.

A commonly reported trend is that juveniles occur in shallow water and adults are found in deeper water (Parrish 1989). Juveniles also tend to feed in different habitats than adults, possibly reflecting a way to reduce predation pressures. Not much is known on the location and characteristics of nursery grounds for juvenile deep slope snappers and groupers. In Hawaii, juvenile opakapaka (*P. filamentosus)* have been found on flat, featureless shallow banks, as opposed to high relief areas where the adults occur. Similarly, juveniles of the deep slope grouper, Hāpu`upu`u (*Epinephelus quernus)* are found in shallow water (Moffitt 1993). Ralston and Williams (1988), however, found that for deep slope species, size was poorly correlated with depth.

The distribution of adult bottomfish is correlated with suitable physical habitat. Because of the volcanic nature of the islands within the region, most bottomfish habitat consists of steep slope areas on the margins of the islands and banks. The habitat of the major bottomfish species tend to overlap to some degree, as indicated by the depth range where they are caught. Within the overall depth range, however, individual species are more common at specific depth intervals.

Depth alone does not assure satisfactory habitat. Both the quantity and quality of habitat at depth are important. Bottomfish are typically distributed in a non-random patchy pattern, reflecting bottom habitat and oceanographic conditions. Much of the habitat within the depths of occurrence of bottomfish is a mosaic of sandy low-relief areas and rocky high relief areas. An important component of the habitat for many bottomfish species appears to be the association of high-relief areas with water movement. In the Hawaiian Islands and at Johnston Atoll, bottomfish density is correlated with areas of high-relief and current flow (Haight 1989, Haight et al. 1993b, and Ralston et al. 1986).

Although the water depths utilized by bottomfish may overlap somewhat, the available resources may be partitioned by species-specific behavioral differences. In a study of the feeding habitats of the commercial bottomfish in the Hawaiian Archipelago, Haight et al. (1993a) found that ecological competition between bottomfish species appears to be minimized through species specific habitat utilization. Species may partition the resource through both the depth and time of feeding activity, and through different prey preferences.

<u>Precious Corals</u>

Currently, there are minimal harvests of precious corals in the Western Pacific Region. In the 1970's to early 1990's, however, precious corals were targeted and an FMP was implemented in 1983 (see Section 1.4). The commonly harvested precious corals include pink coral (*Corallium secundum, Corallium regale, Corallium laauense*), gold coral (*Narella spp*. *Gerardia spp.*, *Calyptrophora spp.*) bamboo coral (*Lepidisis olapa, Acanella spp.*), and black coral (*Antipathes dichotoma*, *Antipathes grandis*, *Antipathes ulex*).

In general, western Pacific precious corals share several ecological characteristics: they lack symbiotic algae in tissues (they are ahermatypic) and most are found in deep water below the euphotic zone; they are filter feeders; and many are fan shaped to maximize contact surfaces with particles or microplankton in the water column. Because precious corals are filter feeders, most species thrive in areas swept by strong to moderate currents (Grigg 1993). Although precious corals are known to grow on a variety of hard substrate, they are most abundant on substrates of shell sandstone, limestone, or basaltic rock with a limestone veneer.

All precious corals are slow growing and are characterized by low rates of mortality and recruitment. Natural populations are relatively stable, and a wide range of age classes is generally present. This life history pattern (longevity and many year classes) has two important consequences with respect to exploitation. First, the response of the population to exploitation is drawn out over many years. Second, because of the great longevity of individuals and the associated slow rates of turnover in the populations, a long period of reduced fishing effort is required to restore the ability of the stock to produce at the maximum sustainable yield (MSY) if a stock has been over exploited for several years.

Because of the great depths at which they live, precious corals may be insulated from some short-term changes in the physical environment, however, not much is known regarding the long-term effects of changes in environmental conditions, such as water temperature or current velocity, on the reproduction, growth, or other life history characteristics of the precious corals (Grigg 1993).

3.2.3 Pelagic Environment

Pelagic species are closely associated with their physical and chemical environment. Suitable physical environment for these species depends on gradients in temperature, oxygen or salinity, all of which are influenced by oceanic conditions on various scales. In the pelagic environment, physical conditions such as isotherm and isohaline boundaries often determine whether or not the surrounding water mass is suitable for pelagic fish, and many of the species are associated with specific isothermic regions. Additionally, areas of high trophic transfer as found in fronts and eddies are important habitat for foraging, migration, and reproduction for many species (Bakun 1996).

The pelagic ecosystem is very large compared to any other marine ecosystems. Biological productivity in the pelagic zone is highly dynamic, characterized by advection of organisms at lower trophic levels and by extensive movements of animals at higher trophic levels, both of which are strongly influenced by ocean climate variability and meso-scale hydrographic features.

Phytoplankton, which contributes to over 95 % of primary production in the marine environment (Valiela 1995), represents several different types of microscopic organisms which require sunlight for photosynthesis. Phytoplankton, which primarily live in the upper 100 m of the euphotic zone of the water column, include organisms such as diatoms, dinoflagellates, coccolithophores, silicoflagellates, and cyanobacteria. Although some phytoplankton have structures (e.g. flagella) which allow them some movement, generally phytoplankton distribution is controlled by current movements and water turbulence.

Diatoms can either be single celled or form chains with other diatoms and mostly found in areas with high nutrient levels such as coastal temperate and polar regions. Diatoms are the largest contributor to primary production in the ocean (Valiela 1995). Dinoflagellates are unicellular (one celled) organisms which are often observed in high abundance in subtropical and tropical regions. Coccolithophores, which also unicellular, are mostly observed in tropical pelagic regions (Levington 1995). Cyanobacteria, or blue-green algae, are often found in warm, nutrient-poor waters of tropical ocean regions.

Oceanic pelagic fish such as skipjack and yellowfin tuna, and blue marlin prefer warm surface layers, where the water is well mixed by surface winds and is relatively uniform in temperature and salinity. Other fish such as albacore, bigeye tuna, striped marlin and swordfish, prefer cooler, more temperate waters, often meaning higher latitudes or greater depths. Preferred water temperature often varies with the size and maturity of pelagic fish, and adults usually have a wider temperature tolerance than sub-adults. Thus, during spawning, adults of many pelagic species usually move to warmer waters, the preferred habitat of their larval and juvenile stages. Large-scale oceanographic events (such as El Niño) change the characteristics of water temperature and productivity across the Pacific, and these events have a significant effect on the habitat range and movements of pelagic species. Tuna are commonly most concentrated near islands and seamounts that create divergences and convergences which concentrate forage species, also near upwelling zones along ocean current boundaries, and along gradients in temperature, oxygen and salinity. Swordfish and numerous other pelagic species tend to concentrate along food-rich temperature fronts between cold, upwelled water and warmer oceanic water masses (NMFS 2001).

These frontal zones have also been found to be likely migratory pathways across the Pacific for loggerhead turtles (Polovina et al. 2000). Loggerhead turtles are opportunistic omnivores that feed on floating prey such as the pelagic cnidarian *Vellela vellela* ("by the wind sailor"), and the pelagic gastropod *Janthia* spp., both of which are likely to be concentrated by the weak downwelling associated with frontal zones (Polovina et al. 2000). Data from on-board observers in the Hawaii-based longline fishery indicate that incidental catch of loggerheads occurs along the 17° C front (STF) during the first quarter of the year and along the 20° C front (SSTF) in the second quarter of the year. The interaction rate, however is substantially greater along the 17° C front (Polovina et al. 2000).

3.2.3.1 Pelagic Species of Economic Importance

The most commonly harvested pelagic species in the Western Pacific Region include: tunas (*Thunnus obesus, Thunnus albacares, Thunnus alalunga, Katsuwonus pelamis*), billfish (*Tetrapturus auda, Makaira mazara, Xiphias gladius),* dolphinfish (*Coryphaena hippurus, C. equiselas)* and wahoo (*Acanthocybium solandri).* Species of oceanic pelagic fish live in tropical and temperate waters throughout the world's oceans. They are capable of long migrations that reflect complex relationships to oceanic environmental conditions. These relationships are different for larval, juvenile and adult stages of life. The larvae and juveniles of most species are more abundant in tropical waters, whereas the adults are more widely distributed. Geographic distribution varies with seasonal changes in ocean temperature. In both the Northern and Southern Hemispheres, there is seasonal movement of tunas and related species toward the pole in the warmer seasons and a return toward the equator in the colder seasons. In the western Pacific, pelagic adult fish range from as far north as Japan to as far south as New Zealand. Albacore, striped marlin and swordfish can be found in even cooler waters at latitudes as far north as latitude 50° N. and as far south as latitude 50° S. As a result, fishing for these species is conducted year-round in tropical waters and seasonally in temperate waters (NMFS 2001).

Migration patterns of pelagic fish stocks in the Pacific Ocean are not easily understood or categorized, despite extensive tag-and-release projects for many of the species. This is particularly evident for the more tropical tuna species (e.g., yellowfin, skipjack, bigeye) which appear to roam extensively within a broad expanse of the Pacific centered on the equator. Although tagging and genetic studies have shown that some interchange does occur, it appears that short life spans and rapid growth rates restrict large-scale interchange and genetic mixing of eastern, central and far-western Pacific stocks of yellowfin and skipjack tuna. Morphometric studies of yellowfin tuna also support the hypothesis that populations from the eastern and western Pacific derive from relatively distinct sub-stocks in the Pacific. The stock structure of bigeye in the Pacific is poorly understood, but a single, Pacific-wide population is assumed. The movement of the cooler-water tuna (e.g., bluefin, albacore) is more predictable and defined, with tagging studies documenting regular and well-defined seasonal movement patterns relating to specific feeding and spawning grounds. The oceanic migrations of billfish are poorly understood, but the results of limited tagging work conclude that most billfish species are capable of transoceanic movement, and some seasonal regularity has been noted (NMFS 2001).

In the ocean, light and temperature diminish rapidly with increasing depth, especially in the region of the thermocline. Many pelagic fish make vertical migrations through the water column. They tend to inhabit surface waters at night and deeper waters during the day, but several species make extensive vertical migrations between surface and deeper waters throughout the day.

Certain species, such as swordfish and bigeye tuna, are more vulnerable to fishing when they are concentrated near the surface at night. Bigeye tuna may visit the surface during the night, but generally, longline catches of this fish are highest when hooks are set in deeper, cooler waters just above the thermocline (275-550 meters or 150-300 fathoms). Surface concentrations of juvenile albacore are largely concentrated where the warm mixed layer of the ocean is shallow (above 90 m or 50 fm), but adults are caught mostly in deeper water (90-275 m or 50-150 fm). Swordfish are usually caught near the ocean surface but are known to venture into deeper waters. Swordfish demonstrate an affinity for thermal oceanic frontal systems which may act to aggregate their prey and enhance migration by providing an energetic gain by moving the fish along with favorable currents (Olsen et al. 1994).

3.3 Essential Fish Habitat and Habitat Areas of Particular Concern

For each FMP and list of MUS (see Section 2.1), the Council has declared Essential Fish Habitat (EFH) and Habitat Areas of Particular Concern (HAPC) (64 FR 19068). The Council and NMFS must ensure that any activities conducting in such areas do not adversely affect, to the extent possible, EFH of HAPC for any MUS. The following table represents the EFH and HAPC for all Western Pacific MUS.

Table 18: Essential Fish Habitat and Habitat Area of Particular Concern for Western Pacific MUS

FMP	EFH (Juveniles and Adults)	EFH (Eggs and Larvae)	HAPC
Coral Reef Ecosystem	Water column and benthic substrate to a depth of 100 m	Water column and benthic substrate to a depth of 100 m	All MPAs identified in FMP, all PRIAs, many specific areas of coral reef habitat
Crustaceans	Bottom habitat from shoreline to a depth of 100 m	Water column down to 150 m	All banks within the NWHI with summits less than 30 m
Bottomfish and Seamount Groundfish	Bottomfish: Water column and bottom habitat down to 400 m Seamount Groundfish: (adults only) water column and bottom from 80 to 600 m, bounded by 29°-35°N and 171°E-179°W	Bottomfish: Water column down to 400 m Seamount Groundfish: (including juveniles) epipelagic zone (0-200m) bounded by 29°-35°N and 171°E-179°W	Bottomfish: All escarpments and slopes between 40-280 m, and three known areas of juvenile *ōpakapaka* habitat Seamount Groundfish: not identified

FMP	EFH (Juveniles and Adults)	EFH (Eggs and Larvae)	HAPC
Precious Corals	Keāhole Point, Makapuu, Kaena Point, Westpac, Brooks Bank, 180 Fathom Bank deep water precious corals (gold and red) beds and Milolii, Auau Channel and S. Kauai black coral beds	Not applicable	Makapuu,Westpac, and Brooks Bank deep water precious corals beds and the Auau Channel black coral bed
Pelagics	Water column down to 1,000 m	Water column down to 200 m	Water column above seamounts and banks down to 1,000 m

As the above table shows, Western Pacific EFH and HAPC fall into two categories: either the water column above the ocean bottom, or the ocean bottom itself. Water column EFH and HAPC have been designated for pelagic, bottomfish, precious corals, crustacean and coral reef ecosystem MUS. Areas of ocean bottom have been designated EFH and HAPC for precious corals, crustaceans, bottomfish and coral reef ecosystem MUS. The use of explosives, poisons, trawl nets, and other destructive gears which may adversely affect any EFH or HAPC in the Western Pacific Region is prohibited. No fishery under Council jurisdiction has been found to adversely affect the EFH or HAPC of any Western Pacific Region MUS.

3.4 Protected Species

To varying degrees, protected species in the Western Pacific Region face various natural and anthropogenic threats to their continued existence such as regime shifts, habitat degradation, poaching, fisheries interactions, vessel strikes, disease, and behavioral alterations from various disturbances associated with human activities.

3.4.1 Sea Turtles

All Pacific sea turtles are designated under the U.S. Endangered Species Act (ESA) as either threatened or endangered. The breeding populations of Mexico olive ridley sea turtles (*Lepidochelys olivacea*) are currently listed as endangered, while all other ridley populations are listed as threatened. Leatherback sea turtles (*Dermochelys coriacea*) and hawksbill turtles (*Eretmochelys imbricata*) are also classified as endangered. Loggerhead (*Caretta caretta*) and green sea turtles (*Chelonia mydas*) are listed as threatened (the green sea turtle is listed as threatened throughout its Pacific range, except for the endangered population nesting on the Pacific coast of Mexico). These five species of sea turtles are highly migratory, or have a highly migratory phase in their life history (NMFS 2001). Generally, impacts to sea turtles in the Western Pacific Region include non-anthropogencially caused ecosystem variability (e.g. regime shifts), predation, habitat degradation (e.g nesting and foraging sites), illegal poaching, tourism activities disrupting behavior, fishery interactions (e.g. hookings or gear entanglements), and marine debris entanglements. A Biological Opinion was issued in February, 2004 by NMFS following a consultation under section 7 of the Endangered Species Act on the ongoing operation of the Western Pacific Region's pelagic fisheries as managed under the Pelagics Fishery Management Plan. That Opinion concluded that the fisheries were not likely to jeopardize the continued existence of any sea turtles under NMFS' jurisdiction, or destroy or adversely modify their designated critical habitat.

3.4.1.1 Leatherback Sea Turtles

Leatherback turtles **(***Dermochelys coriacea*) are widely distributed throughout the oceans of the world, and are found in waters of the Atlantic, Pacific, and Indian Oceans, the Caribbean Sea, and the Gulf of Mexico (Dutton et al. 1999). Increases in the number of nesting females have been noted at some sites in the Atlantic (Dutton et al. 1999), but these are far outweighed by local extinctions, especially of island populations, and the demise of once-large populations throughout the Pacific, such as in Malaysia (Chan and Liew 1996) and Mexico (Spotila et al.1996; Sarti et al.1996). In other leatherback nesting areas, such as Papua New Guinea, Indonesia, and the Solomon Islands, there have been no systematic consistent nesting surveys, so it is difficult to assess the status and trends of leatherback turtles at these beaches. In all areas where leatherback nesting has been documented, however, current nesting populations are reported by scientists, government officials, and local observers to be well below abundance levels of several decades ago. The collapse of these nesting populations was most likely precipitated by a tremendous overharvest of eggs coupled with incidental mortality from fishing (Sarti et al. 1996).

Leatherback turtles are the largest of the marine turtles, with a shell length often exceeding 150 cm and front flippers that are proportionately larger than in other sea turtles and may span 270 cm in an adult (NMFS 1998). The leatherback is morphologically and physiologically distinct from other sea turtles and it is thought that its streamlined body, with a smooth, dermis-sheathed carapace and dorso-longitudinal ridges may improve laminar flow.

Leatherback turtles lead a completely pelagic existence, foraging widely in temperate waters except during the nesting season, when gravid females return to tropical beaches to lay eggs. Males are rarely observed near nesting areas, and it has been proposed that mating most likely takes place outside of the tropical waters, before females move to their nesting beaches (Eckert and Eckert, 1988). Leatherbacks are highly migratory, exploiting convergence zones and upwelling areas in the open ocean, along continental margins and in archipelagic waters (Eckert, 1998). In a single year, a leatherback may swim more than 10,000 kilometers (Eckert 1998).

Satellite telemetry studies indicate that adult leatherback turtles follow bathymetric contours over their long pelagic migrations and typically feed on cnidarians (jellyfish and siphonophores) and tunicates (pyrosomas and salps), and their commensals, parasites and prey (NMFS 1998). Because of the low nutritive value of jellyfish and tunicates, it has been estimated that an adult leatherback would need to eat about 50 large jellyfish (equivalent to approximately 200 liters) per day to maintain its nutritional needs (Duron 1978). Compared to greens and loggerheads, which consume approximately 3-5% of their body weight per day, leatherback turtles may consume 20-30% of their body weight per day (Davenport and Balazs 1991).

Females are believed to migrate long distances between foraging and breeding grounds, at intervals of typically two or four years (Spotila et al. 2000). The mean re-nesting interval of females on Playa Grande, Costa Rica to be 3.7 years, while in Mexico, 3 years was the typical reported interval (L. Sarti, Universidad Naçional Autonoma de Mexico (UNAM), personal communication, 2000 in NMFS 2004). In Mexico, the nesting season generally extends from November to February, although some females arrive as early as August (Sarti et al. 1989). Most of the nesting on Las Baulas takes place from the beginning of October to the end of February (Reina et al. 2002). In the western Pacific, nesting peaks on Jamursba-Medi Beach (Papua, Indonesia) from May to August, on War-Mon Beach (Papua) from November to January (Starbird and Suarez1994), in peninsular Malaysia in June and July (Chan and Liew 1989), and in Queensland, Australia in December and January (Limpus and Reimer 1994).

Migratory routes of leatherback turtles originating from eastern and western Pacific nesting beaches are not entirely known. However, satellite tracking of post-nesting females and genetic analyses of leatherback turtles caught in U.S. Pacific fisheries or stranded on the west coast of the U.S. present some strong insights into at least a portion of their routes and the importance of particular foraging areas. Current data from genetic research suggest that Pacific leatherback stock structure (natal origins) may vary by region. Due to the fact that leatherback turtles are highly migratory and stocks mix in high seas foraging areas, and based on genetic analyses of samples collected by both Hawaii-based and west coast-based longline observers, leatherback turtles inhabiting the northern and central Pacific Ocean are comprised of individuals originating from nesting assemblages located south of the equator in the western Pacific (e.g., Indonesia, Solomon Islands) and in the eastern Pacific along the Americas (e.g., Mexico, Costa Rica) (Dutton et al. 2000).

Recent information on leatherbacks tagged off the west coast of the United States has also revealed an important migratory corridor from central California to south of the Hawaiian Islands, leading to western Pacific nesting beaches. Leatherback turtles originating from western Pacific beaches have also been found along the U.S. mainland. There, leatherback turtles have been sighted and reported stranded as far north as Alaska (60°N) and as far south as San Diego, California (NMFS 1998). Of the stranded leatherback turtles that have been sampled to date from the U.S. mainland, all have been of western Pacific nesting stock origin (P. Dutton, NMFS, personal communication, 2000, in NMFS 2004).

3.4.1.2 Loggerhead Sea Turtles

The loggerhead sea turtle (*Caretta caretta)* is characterized by a reddish brown, bony carapace, with a comparatively large head, up to 25 cm wide in some adults. Adults typically weigh between 80 and 150 kg, with average CCL measurements for adult females worldwide between 95-100 cm CCL (Dodd 1988) and adult males in Australia averaging around 97 cm CCL (Limpus 1985, in Eckert 1993). Juveniles found off California and Mexico measured between 20 and 80 cm (average 60 cm) in length (Bartlett 1989 in Eckert, 1993). Skeletochronological age estimates and growth rates were derived from small loggerheads caught in the Pacific high-seas driftnet fishery. Loggerheads less than 20 cm were estimated to be 3 years old or less, while those greater than 36 cm were estimated to be 6 years old or more. Age-specific growth rates for the first 10 years were estimated to be 4.2 cm/year (Zug et al. 1995).

For their first years of life, loggerheads forage in open ocean pelagic habitats. Both juvenile and subadult loggerheads feed on pelagic crustaceans, mollusks, fish, and algae. The large aggregations of juveniles off Baja California have been observed foraging on dense concentrations of the pelagic red crab, *Pleuronocodes planipes* (Nichols et al. 2000). Data collected from stomach samples of turtles captured in North Pacific driftnets indicate a diet of gastropods (*Janthina* sp.), heteropods (*Carinaria* sp.), gooseneck barnacles (*Lepas* sp.), pelagic purple snails (*Janthina* sp.), medusae (*Vellela* sp.), and pyrosomas (tunicate zooids). Other common components include fish eggs, amphipods, and plastics (Parker et al. 2002).

These loggerheads in the north Pacific are opportunistic feeders that target items floating at or near the surface, and if high densities of prey are present, they will actively forage at depth (Parker et al. 2002). As they age, loggerheads begin to move into shallower waters, where, as adults, they forage over a variety of benthic hard- and soft-bottom habitats (reviewed in Dodd, 1988). Subadults and adults are found in nearshore benthic habitats around southern Japan, in the East China Sea and the South China Sea (e.g., Philippines, Taiwan, and Vietnam).

The loggerhead sea turtle is listed as threatened under the ESA throughout its range, primarily due to direct take, incidental capture in various fisheries, and the alteration and destruction of its habitat. In general, during the last 50 years, North Pacific loggerhead nesting populations have declined 50-90% (Kamezaki et al. 2003). From nesting data collected by the Sea Turtle Association of Japan since 1990, the latest estimates of the numbers of nesting females in almost all of the rookeries are as follows: 1998 - 2,479 nests; 1999 - 2,255 nests; 2000 - 2,589 nests.[7]

In the south Pacific, Limpus (1982) reported an estimated 3,000 loggerheads nesting annually in Queensland, Australia during the late 1970s. However, long-term trend data from Queensland indicate a 50 percent decline in nesting by 1988-89, due to incidental mortality of turtles in the coastal trawl fishery. This decline is corroborated by studies of breeding females at adjacent feeding grounds (Limpus and Reimer 1994). Currently, approximately 300 females nest annually in Queensland, mainly on offshore islands (Capricorn-Bunker Islands, Sandy Cape, Swains Head) (Dobbs 2001). In southern Great Barrier Reef waters, nesting loggerheads have declined approximately 8 percent per year since the mid-1980s (Heron Island), while the foraging ground population has declined 3 percent and comprised less than 40 adults by 1992. Researchers attribute the declines to perhaps recruitment failure due to fox predation of eggs in the 1960s and mortality of pelagic juveniles from incidental capture in longline fisheries since the 1970s (Chaloupka and Limpus 2001).

3.4.1.3 Green Sea Turtles

Green turtles (*Chelonia mydas)* are distinguished from other sea turtles by their smooth carapace with four pairs of lateral “scutes,” a single pair of prefrontal scutes, and a lower jaw-edge that is coarsely serrated. Adult green turtles have a light to dark brown carapace, sometimes shaded with olive, and can exceed one meter in carapace length and 100 kg in body mass. Females nesting in Hawaii averaged 92 cm in straight carapace length (SCL), while at Olimarao Atoll in

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[7] In the 2001, 2002, and 2003 nesting seasons, a total of 3,122, 4,035 and 4,519 loggerhead nests, respectively, were recorded on Japanese beaches (Matsuzawa, March 2005, final report to the WPRFMC).

Yap, females averaged 104 cm in curved carapace length and approximately 140 kg. In the rookeries of Michoacán, Mexico females averaged 82 cm in CCL, while males averaged 77 cm CCL (NMFS1998). Based on growth rates observed in wild green turtles, skeletochronological studies, and capture-recapture studies, all in Hawaii, it is estimated that an average of at least 25 years would be needed to achieve sexual maturity (Eckert 1993).

Although most green turtles appear to have a nearly exclusively herbivorous diet, consisting primarily of sea grass and algae (Wetherall et al.1993), those along the east Pacific coast seem to have a more carnivorous diet. Analysis of stomach contents of green turtles found off Peru revealed a large percentage of mollusks and polychaetes, while fish and fish eggs, and jellyfish and commensal amphipods comprised a lesser percentage (Bjorndal 1997). Seminoff et al. (2000) found that 5.8 percent of gastric samples, and 29.3 percent of the fecal samples of East Pacific green turtles foraging in the northern Sea of Cortez, Mexico contained the remains of the fleshy sea pen *(Ptilosarcus undulatus)*.

The green sea turtles are a circumglobal and highly migratory species, nesting and feeding in tropical/subtropical regions. Their range can be defined by a general preference for water temperature above 20° C. Green sea turtles are known to live in pelagic habitats as post hatchlings/juveniles, feeding at or near the ocean surface. The non-breeding range of this species can lead a pelagic existence many miles from shore. The breeding range primarily live in bays and estuaries and are rarely found in the open ocean. Most migration from rookeries to feeding grounds is via coastal waters with females migrating to breed only once every two years or more (Bjorndal 1997).

Tag returns of eastern Pacific green turtles (often reported as black turtles) establish that these turtles travel long distances between foraging and nesting grounds. In fact, 75 percent of tag recoveries from 1982-1990 were from turtles that had traveled more than 1,000 km from Michoacán, Mexico. Even though these turtles were found in coastal waters, the species is not confined to these areas, as indicated by 1990 sightings records from a NOAA research ship. Observers documented green turtles 1,000-2,000 statute miles from shore (Eckert1993). The east Pacific green is also the second-most sighted turtle in the east Pacific during tuna cruises; they frequent a north-south band from 15° N. to 5° S. along 90° W., and between the Galapagos Islands and the Central American Coast (NMFS1998).

In a review of sea turtle sighting records from northern Baja California to Alaska, Stinson (1984, in NMFS 1998) determined that the green turtle was the most commonly observed sea turtle on the U.S. Pacific coast, with 62 percent reported in a band from southern California and southward. The northernmost (reported) year-round resident population of green turtles occurs in San Diego Bay, where about 30-60 mature and immature turtles concentrate in the warm water effluent discharged by a power plant. These turtles appear to have originated from east Pacific nesting beaches, based on morphology and preliminary genetic analysis (in NMFS and FWS, 1998). California stranding reports from 1990-1999 indicate that the green turtle is the second most commonly found stranded sea turtle (48 total, averaging 4.8 annually) (J. Cordaro, NMFS, pers. comm., April 2000).

Stinson (1984) found that green turtles will appear most frequently in U.S. coastal waters when temperatures exceed 18° C. An east Pacific green turtle was tracked along the California coast by satellite transmitter which was equipped to report thermal preferences of the turtle. This turtle showed a distinct preference for waters that were above 20° (S. Eckert, unpub. data). Subadult green turtles routinely dive to 20 meters for 9-23 minutes, with a maximum recorded dive of 66 minutes (Lutcavage et al. 1997).

The non-breeding range of green turtles is generally tropical, and can extend approximately 500-800 miles from shore in certain regions (Eckert 1993). The underwater resting sites include coral recesses, the undersides of ledges, and sand bottom areas that are relatively free of strong currents and disturbance from natural predators and humans. In the MHI, these foraging and resting areas for adults usually occur at depths greater than ten meters, but probably not normally exceeding 40 m. Available information indicates that the resting areas are in proximity to the feeding pastures. In the Pacific, the only major (> 2,000 nesting females) populations of green turtles occur in Australia and Malaysia. Smaller colonies occur in the insular Pacific islands of Polynesia, Micronesia, and Melanesia (Wetherall et al. 1993) and on six small sand islands at French Frigate Shoals, a long atoll situated in the middle of the Hawaiian Archipelago (Balazs et al.1995).

Green turtles were listed as threatened under the ESA on July 28, 1978, except for breeding populations found in Florida and the Pacific coast of Mexico, which were listed as endangered. Using a precautionary estimate, the number of nesting female green turtles has declined by 48%to 67% over the last three generations (~ 150 yrs) (Troeng and Rankin 2005). Causes for this decline include harvest of eggs, subadults and adults; incidental capture by fisheries; loss of habitat; and disease. The degree of population change is not consistent among all index nesting beaches or among all regions. Some nesting populations are stable or increasing (Balazs and Chalolupka 2004; Troeng and Rankin 2005; Chaloupka and Limpus 2001). However, other populations or nesting stocks have markedly declined. Because many of the threats that have led to these declines have not yet ceased, it is evident that green turtles face a measurable risk of extinction (Troeng and Rankin 2005).

Green turtles in Hawaii are considered genetically distinct and geographically isolated although a nesting population at Islas Revillagigedos in Mexico appears to share the mtDNA haplotype that commonly occurs in Hawaii. In Hawaii, green turtles nest on six small sand islands at French Frigate Shoals, a crescent-shaped atoll situated in Northwestern Hawaiian Islands (Balazs 1995). Ninety to 95 percent of the nesting and breeding activity occurs at the French Frigate Shoals, and at least 50 percent of that nesting takes place on East Island, a 12-acre island. Long-term monitoring of the population shows that there is strong island fidelity within the regional rookery. Low level nesting also occurs at Laysan Island, Lisianki Island and on Pearl and Hermes Reef (NMFS 1998).

Since the establishment of the ESA in 1973, and following years of exploitation, the nesting population of Hawaiian green turtles has shown a gradual but definite increase (Balazs 1996; Balazs and Chaloupka 2004). In three decades the number of nesting females at East Island increased from 67 nesting females in 1973 to 467 nesting females in 2002. Nester abundance increased rapidly at this rookery during the early 1980s, leveled off during the early 1990s before again increasing rapidly during the late 1990s and up to the present. This trend is very similar to the underlying trend in the recovery of the much larger green turtle population that nests at Tortuguero, Costa Rica (Bjorndal et al. 1999). The stepwise increase of the long-term nester trend since the mid-1980s is suggestive, but not conclusive, of a density-dependent adjustment process affecting sea turtle abundance at the foraging grounds (Bjorndal et al. 2000, Balazs and Chaloupka 2004). Balazs and Chaloupka (2004) conclude that the Hawaiian green sea turtle stock is well on the way to recovery following 25 years of protection. This increase can be attributed to increased female survivorship since harvesting of turtles was prohibited in addition to the cessation of habitat damage at the nesting beaches since the early 1950s (Balazs and Chaloupka 2004).

3.4.1.4 Hawksbill Sea Turtles

Hawksbill sea turtles (*Eretmochelys imbricate*) are circumtropical in distribution, generally occurring from latitudes 30° N. to 30° S. within the Atlantic, Pacific and Indian Oceans and associated bodies of water (NMFS 1998). Hawksbills have a relatively unique diet of sponges (Meylan, 1985; 1988). While data are somewhat limited on diet in the Pacific, it is well documented in the Caribbean that hawksbill turtles are selective spongivores, preferring particular sponge species over others (Dam and Diez 1997b). Foraging dive durations are often a function of turtle size with larger turtles diving deeper and longer. At a study site also in the northern Caribbean, foraging dives were made only during the day and dive durations ranged from 19-26 minutes at depths of 8-10 m. At night, resting dives ranged from 35-47 minutes in duration (Dam and Diez, 1997a).

As a hawksbill turtle grows from a juvenile to an adult, data suggest that the turtle switches foraging behaviors from pelagic surface feeding to benthic reef feeding (Limpus 1992). Within the Great Barrier Reef of Australia hawksbills move from a pelagic existence to a “neritic” life on the reef at a minimum CCL of 35 cm. The maturing turtle establishes foraging territory and will remain in this territory until it is displaced (Limpus 1992). As with other sea turtles, hawksbills will make long reproductive migrations between foraging and nesting areas (Meylan, 1999), but otherwise they remain within coastal reef habitats. In Australia, juvenile hawksbill sea turtles outnumber adults 100:1. These populations are also sex biased with females outnumbering males 2.57:1 (Limpus 1992).

Along the far western and southeastern Pacific, hawksbill turtles nest on the islands and mainland of southeast Asia, from China to Japan, and throughout the Philippines, Malaysia, Indonesia, Papua New Guinea, the Solomon Islands (McKeown 1977) and Australia (Limpus 1982).

The hawksbill turtle is listed as endangered throughout its range. In the Pacific, this species is rapidly approaching extinction primarily due to the harvesting of the species for its meat, eggs and shell, as well as the destruction of nesting habitat by human occupation and disruption (NMFS 1998). Along the eastern Pacific rim, hawksbill turtles were common to abundant in the 1930s (Cliffton et al. 1982). By the 1990s, the hawksbill turtle was rare to absent in most localities where it was once abundant (Cliffton et al. 1982). In the Pacific, this species is rapidly approaching extinction primarily due to the harvesting of the species for its meat, eggs, and shell, as well as the destruction of nesting habitat by human occupation and disruption (NMFS 1998).

3.4.1.5 Olive Ridley Sea Turtles

Olive ridley turtles (*Lepidochelys olivacea*) are olive or grayish green above, with a greenish white underpart, and adults are moderately sexually dimorphic (NMFS 1998). Olive ridleys lead a highly pelagic existence (Plotkin 1994). These sea turtles appear to forage throughout the eastern tropical Pacific Ocean, often in large groups, or flotillas. In a three year study of communities associated with floating objects in the eastern tropical Pacific, Arenas et al. (1992) found that 75 percent of sea turtles encountered were olive ridleys and were present in 15 percent of the observations implying that flotsam may provide the turtles with food, shelter, and/or orientation cues in an otherwise featureless landscape. It is possible that young turtles move offshore and occupy areas of surface current convergences to find food and shelter among aggregated floating objects until they are large enough to recruit to the nearshore benthic feeding grounds of the adults, similar to the juvenile loggerheads mentioned previously.

While it is true that olive ridleys generally have a tropical range, individuals do occasionally venture north, some as far as the Gulf of Alaska (Hodge and Wing 2000). The post-nesting migration routes of olive ridleys, tracked via satellite from Costa Rica, traversed thousands of kilometers of deep oceanic waters ranging from Mexico to Peru and more than 3,000 kilometers out into the central Pacific (Plotkin 1994). Stranding records from 1990-1999 indicate that olive ridleys are rarely found off the coast of California, averaging 1.3 strandings annually (J. Cordaro, NMFS, pers. comm., April 2000).

The olive ridley turtle is omnivorous and identified prey include a variety of benthic and pelagic prey items such as shrimp, jellyfish, crabs, snails, and fish, as well as algae and sea grass (Marquez 1990). It is also not unusual for olive ridley turtles in reasonably good health to be found entangled in scraps of net or other floating synthetic debris. Small crabs, barnacles and other marine life often reside on debris and are likely to attract the turtles. Olive ridley turtles also forage at great depths, as a turtle was sighted foraging for crabs at a depth of 300 m (Landis 1965 in Eckert et al. 1986). The average dive lengths for adult females and males are reported to be 54.3 and 28.5 minutes, respectively (Plotkin 1994 in Lutcavage and Lutz 1997).

Declines in olive ridley populations have been documented in Playa Nancite, Costa Rica; however, other nesting populations along the Pacific coast of Mexico and Costa Rica appear to be stable or increasing, after an initial large decline due to harvesting of adults. Historically, an estimated 10 million olive ridleys inhabited the waters in the eastern Pacific off Mexico (Cliffton et al. 1982 *in* NMFS and USFWS 1998e). However, human-induced mortality led to declines in this population. Beginning in the 1960s, and lasting over the next 15 years, several million adult olive ridleys were harvested by Mexico for commercial trade with Europe and Japan. (NMFS and USFWS 1998e). Although olive ridley meat is palatable, it was not widely sought; its eggs, however, are considered a delicacy, and egg harvest is considered one of the major causes for its decline. Fisheries for olive ridley turtles were also established in Ecuador during the 1960s and 1970s to supply Europe with leather (Green and Ortiz-Crespo 1982). In the Indian Ocean, Gahirmatha supports perhaps the largest nesting population; however, this population continues to be threatened by nearshore trawl fisheries. Direct harvest of adults and eggs, incidental capture in commercial fisheries, and loss of nesting habits are the main threats to the olive ridley's recovery.

3.4.2 Marine Mammals

Cetaceans listed as endangered under the ESA and that have been observed in the Western Pacific Region include the humpback whale (*Megaptera novaeangliae*), sperm whale (*Physeter macrocephalus*), blue whale (*Balaenoptera musculus*), fin whale (*B. physalus*) and sei whale (*B. borealis*). In addition, one endangered pinniped, the Hawaiian monk seal (*Monachus schauinslandi*), occurs in the region. Generally, impacts to marine mammals in the Western Pacific Region include non-anthropogencially caused ecosystem variability (e.g. regime shifts), shark predation, habitat degradation (e.g. birthing and calving areas), tourism activities disrupting behavior, fishery interactions (e.g. gear entanglements), marine debris entanglements, and vessel collisions. No Western Pacific Region fisheries have been found to jeopardize the continued existence of endangered marine mammals. With the exception of the Hawaii-based longline fishery (Category I), all Western Pacific Region fisheries are Category III fisheries under Section 118 of the Marine Mammal Protection Act (69 FR 48407, August 10, 2004).

3.4.2.1 Humpback Whale

Humpback whales (*Megaptera novaeangliae*) can attain lengths of 16 m. Humpback whales winter in shallow nearshore waters of usually 100 fathoms or less. Mature females are believed to conceive on the breeding grounds one winter and give birth the following winter. Genetic and photo identification studies indicate that within the U.S. EEZ in the North Pacific there are at least three relatively separate populations of humpback whales that migrate between their respective summer/fall feeding areas to winter/spring calving and mating areas (Hill and DeMaster 1999). The Central North Pacific stock of humpback whales winters in the waters of the Main Hawaiian Islands (Hill et al*.* 1997). It is not unusual to observe humpback whales during the months of October to May in the nearshore waters off of the island of O'ahu. Another northern hemisphere stock of humpbacks uses the northwestern part of the Philippine Sea in winter. Some animals of this stock move south to the Northern Mariana Islands, including Saipan and Guam. Sightings have been reported in Guam in January and February (Reeves et al. 1999). At least six well-defined breeding stocks of humpback whales occur in the southern hemisphere. Humpbacks arrive in American Samoa from the south between June and December (Reeves et al.1999). This area is probably another calving area and mating ground for the New Zealand group of Antarctic humpbacks.

There is no precise estimate of the worldwide humpback whale population. The humpback whale population in the North Pacific ocean basin is estimated to contain 6,000 to 8,000 individuals (Calambokidis et al.1997). The Central North Pacific stock appears to have increased in abundance between the early 1980s and early 1990s; however, the status of this stock relative to its optimum sustainable population size is unknown (Hill and DeMaster 1999).

3.4.2.2 Sperm Whale

The sperm whale (*Physeter macrocephalus*) is an easily recognizable whale with a darkish gray brown body and a wrinkled appearance. The head of the sperm whale is very large, comprising up to 40 percent of its total body length. The average size for male sperm whales is about 15 m, with females reaching up to 12 m.

Sperm whales are found in tropical to polar waters throughout the world (Rice 1989). They are among the most abundant large cetaceans in the region. Sperm whales have been sighted around several of the Northwestern Hawaiian Islands (Rice 1960) and off the main islands of Hawaii (Lee 1993). In the early to mid 19^{th} century, Hawaii was the center of the whaling operations targeting sperm whales. The sounds of sperm whales have been recorded throughout the year off Oahu (Thompson and Freidl 1982). Sightings of sperm whales were made during May-July in the 1980s around Guam, and in recent years strandings have been reported on Guam (Reeves et al. 1999). Historical observations of sperm whales around Samoa occurred in all months except February and March (Reeves et al. 1999). The north Pacific sperm whale populations is estimated at nearly 40,000 (NMFS 2005).

3.4.2.3 Blue Whale

The blue whale (*Balaenoptera musculus*) is the largest living animal. Blue whales can reach lengths of 30 m, and weights of 160 tons (360,000 lbs) with females usually larger than males of the same age. They occur in all oceans, usually along continental shelves, but can also be found in the shallow inshore waters, and the high seas. No sightings or strandings of blue whales have been reported in Hawaii, but acoustic recordings made off Oahu and Midway islands have reported blue whales somewhere within the EEZ around Hawaii (Thompson and Friedl, 1982).The stock structure of blue whales in the North Pacific is uncertain (Forney et al. 2000). The status of this species in Hawaii waters relative to the optimum sustainable population is unknown, and there are insufficient data to evaluate trends in abundance (Forney et al. 2000).

3.4.2.4 Fin Whale

Fin whales (*Balaenoptera physalus*) are found throughout all oceans and seas of the world from tropical to polar latitudes (Forney et al. 2000). Although it is generally believed that fin whales make poleward feeding migrations in summer and move towards the equator in winter, few actual observations of fin whales in tropical and subtropical waters have been documented, particularly in the Pacific Ocean away from continental coasts (Reeves et al.1999). There have only been a few sightings of fin whales in Hawaii waters.

There is insufficient information to accurately determine the population structure of fin whales in the North Pacific, but there is evidence of multiple stocks (Forney et al. 2000). The status of fin whales in Hawaii waters relative to the optimum sustainable population is unknown, and there are insufficient data to evaluate trends in abundance (Forney et al. 2000).

3.4.2.5 Sei Whale

Sei whales (*Balaenoptera borealis*) have a worldwide distribution but are found mainly in cold temperate to subpolar latitudes rather than in the tropics or near the poles (Horwood 1987). They are distributed far out to sea and do not appear to be associated with coastal features. Two sei whales were tagged in the vicinity of the Northern Mariana Islands (Reeves et al.1999). Sei whales are rare in Hawaii waters. The International Whaling Commission only considers one stock of sei whales in the North Pacific, but some evidence exists for multiple populations (Forney et al. 2000). In the southern Pacific most observations have been south of 30° S (Reeves et al.1999).

There are no data on trends in sei whale abundance in the North Pacific (Forney et al. 2000). It is especially difficult to estimate their numbers because they are easily confused with Bryde's whales which have an overlapping, but more subtropical, distribution (Reeves et al. 1999).

3.4.2.6 Hawaiian Monk Seal

The Hawaiian monk seal (*Monachus schauinslandi*) is a tropical seal endemic to the Hawaiian Islands. Today, the entire population of Hawaiian monk seals is about 1,300 to1, 400 and occurs mainly in the NWHI. The six major reproductive sites are French Frigate Shoals, Laysan Island, Lisianski Island, Pearl and Hermes Reef, Midway Atoll and Kure Atoll. Small populations at Necker Island and Nihoa Island are maintained by immigration, and a few seals are distributed throughout the MHI.

The sub-population of monk seals on French Frigate Shoals has shown the most change in population size, increasing dramatically in the 1960s-1970s and declining in the late 1980s-1990s. In the 1960s-1970s, the other five sub-populations experienced declines. However, during the last decade the number of monk seals increased at Kure Atoll, Midway Atoll and Pearl and Hermes Reef while the sub-populations at Laysan Island and Lisianski Island remained relatively stable. The recent sub-population decline at French Frigate Shoals is thought to have been caused by male aggression, shark attack, entanglement in marine debris, loss of habitat and decreased prey availability. The Hawaiian monk seal is assumed to be well below its optimum sustainable population, and, since 1985, the overall population has declined approximately three percent per year (Forney et al. 2005).

3.4.2.7 Other Marine Mammals

All marine mammals are protected under the Marine Mammal Protection Act. The following table represents the list of known non-ESA listed marine mammals which occur in the Western Pacific Region.

Table 19: Non-ESA Listed Marine Mammals of the Western Pacific Region

Common Name	Scientific Name	Common Name	Scientific Name
Blainsville beaked whale	*(Mesoplodon densirostris*)	Pygmy sperm whale	*Kogia breviceps*

Bottlenose dolphin	(*Tursiops truncatus)*
Bryde's whale	(*Balaenoptera edeni*)
Cuvier's beaked whale	*Ziphius cavirostris*
Dwarf sperm whale	*Kogia simus*
False killer whale	*Pseudorca crassidens*
Killer whale	*Orcinus orca*
Melon-headed whale	*Peponocephala electra*
Pygmy killer whale	*Feresa attenuata*
Fraser's dolphin	*Lagenodelphis hosei*
Longman's beaked whale	*Indopacetus pacificus*

Risso's dolphin	*Grampus griseus*
Rough-toothed dolphin	*Steno bredanensis*
Short-finned pilot whale	*Globicephala macrorhynchus*
Spinner dolphin	*Stenella longirostris*
Spotted dolphin	*Stenella attenuata*
Striped dolphin	*Stenella coeruleoalba*
Pacific white-sided dolphin	*Lagenorhynchus obliquidens*
Minke whale	*Balaenoptera acutorostrata*
Dall's porpoise	*Phocoenoides dalli*

3.4.3 Seabirds

Seabirds are widely distributed through the Western Pacific Region and generally are high trophic level predators. Generally, impacts to seabirds include non-anthropogencially caused ecosystem variability (e.g. regime shifts), habitat degradation (e.g. nesting areas), invasive species (e.g. rats and cats), fishery interactions (e.g. hookings and gear entanglements), marine debris entanglements, and collisions with airplanes. The only documented Western Pacific Region fishery interactions with seabirds have been with the Hawaii-based longline fleet, which is known to result in the inadvertent hooking and entangling of black-footed and Laysan albatrosses. On rare occasions wedge-tailed and sooty shearwaters are also incidentally caught by these vessels (NMFS 2005).

3.4.3.1 Short-tailed Albatross

The short-tailed albatross (*Phoebastria immutabilis*) is the largest seabird in the North Pacific with a wingspan of more than 3 m (9 ft) in length. It is characterized by a bright pink bill with a light blue tip and defining black line extending around the base. The plumage of a young fledgling (i.e., a chick that has successfully flown from the colony for the first time) is brown and at this stage, except for the bird's pink bill and feet, the seabird can easily be mistaken for a black-footed albatross. As the juvenile short-tailed albatross matures, the face and underbody become white and the seabird begins to resemble a Laysan albatross. In flight, however, the short-tailed albatross is distinguished from the Laysan albatross by a white back and by white patches on the wings. As the short-tailed albatross continues to mature, the white plumage on the crown and nape changes to a golden-yellow.

Before the 1880s, the short-tailed albatross population was estimated to be in the millions and it was considered the most common albatross species ranging over the continental shelf of the United States (DeGange 1981). Between 1885 and 1903, an estimated five million short-tailed albatrosses were harvested from the Japanese breeding colonies for the feather, fertilizer, and egg trade, and by 1949 the species was thought to be extinct (Austin 1949). In 1950, ten short-tailed albatrosses were observed nesting on Torishima (Tickell 1973).

The short-tailed albatross is known to breed only in the western North Pacific Ocean, south of the main islands of Japan. Although at one time there may have been more than ten breeding locations (Hasegawa 1979), today there are only two known active breeding colonies, Minami Tori Shima Island and Minami-Kojima Island. On December 14, 2000, one short-tailed albatross was discovered incubating an egg on Yomejima Island of the Ogasawara Islands (southernmost island among the Mukojima Islands). A few short-tailed albatrosses have also been observed attempting to breed, although unsuccessful, at Midway Atoll in the NWHI.

Historically, the short-tailed albatross ranged along the coasts of the entire North Pacific Ocean from China, including the Japan Sea and the Okhotsk Sea (Sherburne 1993) to the west coast of North America. Prior to the harvesting of the short-tailed albatross at their breeding colonies by Japanese feather hunters, this albatross was considered common year-round off the western coast of North America (Robertson 1980 In 2000, the breeding population of the short-tailed albatross was estimated at approximately 600 breeding age birds with an additional 600 immature birds, yielding a total population estimate of 1,200 individuals (65 FR 46643, July 31, 2000). At that time, short-tailed albatrosses were estimated to have an overall annual survival rate of 96 percent and a population growth rate of 7.8 percent (65 FR 46643, July 31, 2000). More recently NMFS estimated the global population to consist of approximately 1,900 individuals (P. Sievert, pers. comm. in NMFS 2005), and the Torishima population was estimated to have increased by 9 percent between the 2003-2004 and 2004-2005 seasons (Harrison 2005).

The short-tailed albatross was first listed under the Endangered Foreign Wildlife Act in June 1970. On July 31, 2000, the USFWS extended the endangered status of the short-tailed albatross to include the species' range in the United States. The primary threats to the species are destruction of breeding habitat by volcanic eruption or mud and land slides, reduced genetic variability, limited breeding distribution, plastics ingestion, contaminants, airplane strikes, and incidental capture in longline fisheries.

3.4.3.2 Newell's Shearwater

The Newell's shearwater (*Puffinus auricularis newelli*) is listed as threatened under the ESA. Generally, the at-sea distribution of the Newell's shearwater is restricted to the waters surrounding the Hawaiian Archipelago, with preference given to the area east and south of the main Hawaiian Islands. The Newell's shearwater has been listed as threatened because of its small population size, approximately 14,600 breeding pairs, its isolated breeding colonies and the numerous hazards affecting them at their breeding colonies (Ainley et al. 1997). The

Newell’s shearwater breeds only in colonies on the main Hawaiian Islands (Ainley et al. 1997), where it is threatened by urban development and introduced predators like rats, cats, dogs, and mongooses (Ainley et al. 1997).

Shearwaters are most active in the day and skim the ocean surface while foraging. During the breeding season, shearwaters tend to forage within 50-62 miles (80-100 km) from their nesting burrows (Harrison 1990). Shearwaters also tend to be gregarious at sea and the Newell’s shearwater is known to occasionally follow ships (Harrison 1990). Shearwaters feed by surface-seizing and pursuit-plunging (Warham 1990). Often shearwaters will dip their heads under the water to sight their prey before submerging (Warham 1990).

Shearwaters are extremely difficult to identify at sea, as the species is characterized by mostly dark plumage, long and thin wings, a slender bill with a pair of flat and wide nasal tubes at the base, and dark legs and feet. Like the albatross, the nasal tubes at the base of the bill enhances the bird’s sense of smell, assisting them to locate food while foraging (Ainley *et al*. 1997).

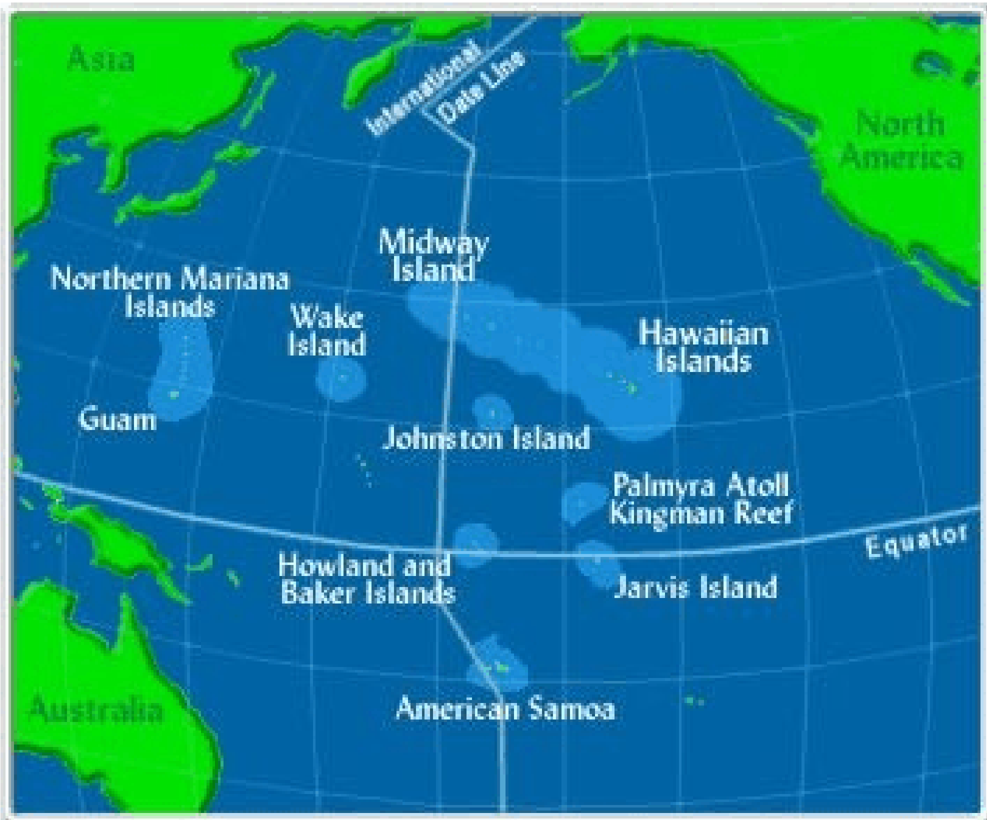
3.4.3.3 Other Seabirds

Other seabirds found in the region include, but are not limited to: black-footed albatross (*Phoebastria nigripes*); Laysan albatross (*Phoebastria immutabilis*), Masked booby (*Sula dactylatra*); brown booby (*Sula leucogaster*); red-footed booby (*Sula sula,*); wedge-tailed shearwater (*Puffinus pacificus*); Christmas shearwater (*Puffinus nativitatis*), petrels (p*seudobulweria* spp*., Pterodroma* spp.*),* tropicbirds (*Phaethon spp.),* frigatebirds (*Fregata* spp.) and noddies (*Anous* spp.)

3.5 The Western Pacific Region

Under the MSA, the U.S. Pacific island possessions are collectively defined as the Pacific Insular Area, which is made up of the EEZ around the Territories of American Samoa and Guam, the Commonwealth of the Northern Mariana Islands, the State of Hawaii, and other U.S. possessions of Jarvis Island, Johnston Atoll, Wake Island, Howland and Baker Islands, Kingman Reef, Palmyra Atoll, and Midway Atoll (Figure 9). At nearly 1.5 million nm², the Pacific Insular Area is the largest fisheries management area in the U.S. This tremendous region stretches across the Pacific Ocean, beyond the dateline and below the equator, and comprises an area of jurisdiction of the Western Pacific Regional Fishery Management Council. For the purposes of this analysis, this area is known as the Western Pacific Region. This section provides specific information o each island area including summaries of local marine features, resources, fisheries, and economies.

Figure 8: The Western Pacific Region



3.5.1 American Samoa

American Samoa, because of the excellent harbor at Pago Pago, Tutuila, has been a U.S. territory since 1899. American Samoa is over 89 percent native Samoan. They are descended from the aboriginal people, who prior to discovery by Europeans, occupied and exercised sovereignty in the area now known as Samoa. Western Samoa is now Independent Samoa. Eastern Samoa is known as American Samoa. New Zealand occupied Western Samoa in 1914 and in 1962 Western Samoa gained independence. In 1997 Western Samoa changed its name to Samoa. The demarcation between Samoa and American Samoa is political. Cultural and commercial exchange continues with families living and commuting between Eastern and Western Samoa.

Approximately 95 percent of the landmass in American Samoa is held under the traditional land tenure system and under the direct authority of the Samoan chiefs known as "matais". Under this system, traditional land cannot be purchased or sold and the current reigning chief from within the family unit has final say over the disposition of a family's holdings. This system ensures the passage of assets to future generations and serves as the catalyst in the preservation of the Samoan culture.

The five volcanic islands, which are the major inhabited islands of American Samoa, are Tutuila, Aunu'u, Ofu, Olosega and Ta'u. Tutuila, the largest island (55 sq miles), is the center of government and business. Aunu'u, a satellite of Tutuila, lies a quarter mile off the coast. The 3 islands of Ofu, Olosega and Ta'u, collectively referred to as the Manu'a islands (with a total land area of less than 20 sq miles), lie 70 miles east of Tutuila. Swains Island with a population of approximately 30 lies 200 miles north of Tutuila, and the uninhabited Rose Atoll is a national sanctuary. Tutuila, Manua and Rose Atoll are between the 14°-15° S latitude and Swains Island lies at 11° S latitude. Swains Island is, geographically, a member of the Tokelau archipelago. The region is geologically inactive and there are few seamounts or guyots in comparison to other Polynesian states. The majority of islands rise from deep (4,000 m) oceanic depths.

The total land mass of American Samoa is about 200 km², surrounded by an EEZ of approximately 390,000 km². The largest island, Tutuila, is nearly bisected by Pago Pago Harbor, the deepest and one of the most sheltered embayments in the South Pacific. Aunu'u is a small island one-quarter mile off the eastern shore of Tutuila. The Manua islands include Ofu, Olosega and Ta'u located 60 miles east of Tutuila. Rose Atoll is a wildlife refuge 60 miles east of Manu'a.

American Samoa experiences southeast trade winds that result in frequent rains and a warm tropical climate. The year round air temperatures range from 70° to 90° F. Humidity averages 80 percent during most of the year. The average rainfall at Pago Pago International Airport is 130 inches per year, while Pago Pago Harbor, only 4.5 miles away, receives an average of 200 inches of rainfall per year (TPC/Dept. of Commerce 2000).

3.5.1.1 Marine Environment

Coral Reefs

The potential coral reef area (includes seagrass beds, sandy and rocky rubble areas) in American Samoa is estimated at 55 km² (within10 fm curve) and 464 km² (within 100 fm curve), respectively (Rohmann et al. in press). Within the 10 fm curve, the estimated coral reef area of: Tutuila is 35.8 km², Ofu and Olesega is 3.8 km², Tau is 3.7 km², Rose Atoll is 8.0 km², and Swains Island is 3.5 km² (Rohmann et al. in press). The structure and development of most of these reefs, except the submerged banks, has been well described in recent years (Maragos et al. 1994, Green 1997).

The condition of coral reef communities American Samoa have also been well described by numerous quantitative and qualitative surveys including: Birkeland et al. 1987, 1994, 1996, Hunter et al. 1993, Maragos 1994, Maragos et al. 1994, Mundy 1996, Green 1996a, Green and Craig 1996). In general, the reefs adjacent to human population centers (e.g. Tutuila Island) appear to be worse condition than those on less populated or unpopulated islands (e.g. the Manu'a Group and the two remote atolls)(Green 1996a).

The reefs of American Samoa have been badly damaged by a combination of natural and anthropogenic disturbances in the last two decades. These include a severe outbreak of the crown-of-thorns starfish in the 1970s, four major cyclones in the last 18 years, and a mass coral bleaching events in 1994, 2002, and 2003 (Maragos et al. 1994, Birkeland et al. 1996, Green

1996a, Craig et al. 2005). In some locations (especially Pago Pago Harbor), these reefs also appear to have been degraded by a combination of anthropogenic processes, including coastal construction, sedimentation, eutrophication, chemical and solid waste pollution (Maragos et al. 1994, Green 1996a, Craig et al. 2005).

Long term monitoring show that these disturbances have resulted in major changes to the coral and fish communities on the island over the last 20-80 years (Birkeland et al.1996). The rate of recovery of the coral reef communities on Tutuila appears to be quite variable. The reefs in Fagatele Bay National Marine Sanctuary (FBNMS) and at most other locations are recovering well from these disturbances (Birkeland et al. 1987. 1994, 1996, Green 1996a). In contrast, the reefs in Pago Pago Harbor and at several other locations around the island are not (Birkeland et al. 1987. 1994, 1996, Mundy 1996). Differences in water quality among sites may be partly responsible for these differences among reefs. For example, the reefs in good condition, including those at FBNMS, Leone, Fatumafuti and Vatia, appear to have good water quality (Mundy 1996, Green 1996a, Green et al. ms). By comparison, the reefs that are in poor condition appear to have poor water quality, including high sediment loads and the presence of chemical pollutants (Maragos et al. 1994, Mundy 1996, Green 1996a). Poor quality reefs include most of the reefs in Pago Pago Harbor and some reefs on the northwest shore (Fagasa and Fagafue) (Maragos et al. 1994, Mundy 1996, Green 1996a).

In general, the reefs on the other, less populated, islands appear to be in good condition (Green 1996a, Mundy 1996). The small island of Aunu'u Island has suffered the same natural disturbances as Tutuila such as coral bleaching and tropical storms. However, they are relatively protected from anthropogenic effects, and have been observed to recover quickly from the area's frequent storms (Mundy 1996, Green 1996a).

The reefs of the Manu'a Islands (Ofu, Olosega and Ta'u) were severely damaged by Hurricane Tusi in 1987. The starfish invasion in the 1970s and the recent coral bleaching event also affected these reefs, but the extent of the damage is unclear (Green 1996a). Several studies over the last ten years have shown that the reefs of the Manu'a Group tend to be in better condition than those around Tutuila (Itano & Buckley 1988, Maragos et al. 1994, Mundy 1996, Green 1996a). In fact, Green (1996a) and Mundy (1996) reported that some of the reefs in Manu'a were among the best surveyed in the archipelago, including reefs on Ofu (Asaga), Olosega (Sili and Olosega Village) and Ta'u (Lepula and Afuli). The shallow lagoon in the National Park is also in particularly good condition (Hunter et al. 1993, Green 1996a, see Non-consumptive Resources). In general, anthropogenic effects are less pronounced in the Manu'a Islands, because of the lower population on these islands. However, the future of some of these reefs is threatened by road construction immediately adjacent to the shoreline on all three islands (Green and Mundy 1995, Green 1996a). Intermittent, moderate to large infestations of the crown-of-thorns starfish may also threaten the condition of some of these reefs in future, especially on Ofu and Olosega (Zann 1992, Mundy 1996)

Benthic Habitat

Due to the steepness of the Tutuila and the other islands which make up American Samoa, most of the available benthic habitat is composed of fringing coral reefs, a limited reef slope, and a few offshore banks (Craig et al. 2005). The islands are fringed by narrow reef flats (50-500 m) that drop to a depth of 3 to 6 m and descend gradually to 40 m. From this depth, the ocean bottom drops rapidly, reaching depths of 1,000 m within 1 to 3 km from shore. The following four banks around Tutuila have been identified: Taputapu, Mataula, Leone West Banks, and Steps Point (Severance and Franco 1989).

Pelagic Habitat

The islands of the Samoa archipelago are an area of modest productivity relative to areas to the north and west. The region is traversed by two main currents: the southern branch of the westward-flowing South Equatorial Current during June - October and the eastward-flowing South Equatorial Counter Current during November - April. Surface temperatures vary between 27°-29° C and are highest in the January - April period. The upper limit of the thermocline in ocean areas is relatively shallow (27° C isotherm at 100m depth) but the thermocline itself is diffuse (lower boundary at 300m depth).

Surface currents: As discussed in Section 3.1.6, ocean circulation is mainly driven by winds and changes in temperature and salinity which affect seawater density. Divergent currents bring nutrient rich waters to the surface, which promotes phytoplankton growth, whereas convergent currents may accumulate forage items important for species distribution. The Westwind Drift (40°-50° S) and the equatorial current system create an anticlockwise current flow or gyre in the south Pacific. From the equator to 20° S, four main currents or countercurrents are recognized (Bigelow 1997).

The northern branch of the South Equatorial Current (SECN) flows westward between 10° N and 7° S at a mean speed of 30 cm/sec and is 200 m thick. The southern branch of the South Equatorial Current (SECS) flows westward between 11° and 14° S at a mean speed of 5 cm/sec and is 200 m thick (Bigelow 1997).

Between these two westward flowing currents is the eastward flowing South Equatorial Countercurrent (SECC) at 7° S - 11° S. The SECC has a mean speed of 20 cm/sec and is 50-100 m thick. South of 15° S the South Tropical Countercurrent (STCC) flows eastward (Bigelow 1997).

Current systems in the south Pacific are not simple latitudinal features as vertical profiles of the equatorial western Pacific show a complex and dynamic stratification of currents (Delcroix et al. 1992). Current velocity fields affecting the American Samoa EEZ are weak with maximum velocity of about 25 cm sec (52 cm sec = 1 knot). In general, current velocities appear southwesterly in the north (5°-10° S), and southerly between 10° and 15° S. The northern branch of the South Equatorial Current (SECN) is the strongest current in the south Pacific. The SECN flows westward and usually attains its maximum velocities within 5° of the equator during March and April (Picaut & Tournier 1991). The SECN mainly affects American Samoa EEZ from January to June.

The southern branch of the South Equatorial Current (SECS) flows westward but is weaker than the SECN. In the central Pacific it may fragment into a series of vortexes (Picaut and Tournier

1991). The SECS is evident to the north of 20° S each month and is strongest from May to October. The South Equatorial Countercurrent (SECC) shares a northern boundary with the westward flowing SECN and a southern boundary with the westward flowing SECS. From observational oceanographic studies in the western Pacific, the SECC flows eastward and in June or July its area of maximum velocity shifts abruptly from 10° S to 7° S, and it may fragment into branches which interrupt the flow of the SECN. In the central Pacific, the SECC is evident to the south of 10° S during November to April, during which time the velocity of the SECS is reduced. From May to October the SECS strengthens and the SECC is not evident in the climatology.

Water temperatures: Although, a 100-m deep pool of uniformly warm (>29° C) water extends over the equatorial western Pacific within 10° N to 10° S (Delcroix et al. 1992), virtually all of the EEZ waters around American Samoa lie farther to the south than the western Pacific warm pool in the more saline and cooler waters of the subtropical south Pacific. Bimonthly sea surface temperature (SST) fields were estimated from a climatology based on an optimal interpolation (OI) analysis of in situ ship and buoy data collected from 1950 to 1979 (Reynolds and Smith 1994). In American Samoa the SST is warmest during January and February and coolest during July and August. Part of the northern portion of the American Samoa EEZ is isothermal (29° C) during January to June. Sea surface temperatures show a north-south gradient, and seasonal variation increases with latitude.

A SST time-series was estimated from 1982 to 1996 for an area north and south of 15° S. Monthly SST was estimated from blended in situ (ship and buoy) SST data and satellite retrievals (Reynolds and Smith 1994). Throughout the time-series the southern area had a greater annual range in SST (2°-5° C) than the northern area (0.5°-1.50° C). The three major El Nino or warm-events that occurred over the time-series (1982-83, 1986-87 and 1991-95) resulted in 10° C cooler winter SSTs (240° C) in the southern area than in normal years. The one major La Nina or cold-event that occurred in 1988-89 resulted in cooler summer SSTs in the northern area than in normal years, but had little affect on the southern area (Reynolds and Smith 1994).

While SST is a convenient indicator of water temperature, the subsurface thermal structure has a greater influence on the horizontal and vertical distribution of some economically important species including tunas. Two measurements used by oceanographers to characterize the subsurface thermal structure are the depth of the mixed layer and the depth of the lower boundary of the thermocline. The mixed layer is a relatively homogeneous layer of near surface water where the temperature remains constant with depth, while the thermocline is a region in the water column where temperature declines rapidly over a relatively small depth range. In tropical waters, the depth of the 27° C isotherm is commonly used as the lower boundary of the mixed layer (Cayre et al. 1989); however, the lower boundary of the thermocline is more difficult to define. For the purposes of this document, the depth of the 15° C isotherm is considered as the lower thermocline depth as suggested by Toole et al. (1988).

Subsurface temperature data, compiled from expendable bathythermographs (XBTs), was used by Bigelow et al. to develop a time-series of profile of temperature with depth for the neighboring Cook Islands between 1982 to 1996. A total of 2,665 profiles were taken from a large area of the Cook Islands EEZ (5°-25° S, 170°-150 ° W). During this period 15 profiles were made per month. The isotherm depths show very different time-series patterns for the two areas. In the northern area, at a range of latitude similar to American Samoa's EEZ, isotherms were 50-100 m shallower after the strong ENSO event of 1982-83. In contrast isotherm depths showed little temporal variability in the southern area. The average depth of the 27° C isotherm in the northern area was 100 m. The lower boundary of the thermocline was deeper in the southern area (330 m) compared to the northern area (275 m) (Bigelow, 1997).

The latitudinal distribution of oxygen with depth was derived from a climatology study based on historical research ship data (Levitus 1982). There is a latitudinal gradient in dissolved oxygen as northern latitudes have less oxygen at a given depth than southern latitudes. In waters south of 15° S, oxygen concentrations are generally high (>3.5 ml O2/liter above 300 m) and should not limit the vertical distribution of tuna. In contrast, catch ability of yellowfin and bigeye is increased between 5° and 10° S because dissolved oxygen concentrations are low (<3.0 ml O2/liter below 250 m) which effectively restricts their vertical habitat (Bigelow 1997).

A monthly productivity climatology model derived from the Coastal Zone Color Scanner (CZCS) based on data from 1978 to 1986 gives an indication of relative productivity. Within the Pacific, primary production is high in the equatorial western Pacific and the tropical eastern Pacific. In contrast, oceanic waters near American Samoa are low in productivity (~0.05 mg/m3) compared to the Society Islands in French Polynesia (>0.1 mg in). There is little intra-annual variation in productivity within the American Samoa fishing zone, but waters to the northeast of 10° S have high productivity during winter months (May-August) (Bigelow 1997).

A long-term shift in the physical environment of the equatorial Pacific Ocean began in 1977 (Miller et al. 1994). Conditions included more clouds, more rainfall, warmer sea surface temperatures and weaker trade winds, similar to a weak decadal El Nino state. They were most pronounced in the central equatorial Pacific, thus American Samoa was close to the center of this shift, which persisted until 1999 (J.Polovina, pers comm.).

3.5.1.2 Protected Species

Sea Turtles

The information regarding sea turtles in American Samoa has come from highly opportunistic tagging of turtles and from dead (stranded) turtles. Hawksbill and green turtles are the most common species found in local waters. There is one record of a leatherback turtle that was incidentally captured about 5 km south of Swains Island and three records of olive ridleys (two dead and one live sighting) (Utzurrum 2002). Hawksbill and green turtle populations have declined precipitously in American Samoa (Grant et al. 1997). Despite Federal and territorial laws prohibiting the killing of sea turtles and an extensive education program, some sea turtles and eggs are still harvested illegally in American Samoa (Grant et al. 1997). In addition to direct take of turtles and eggs, degradation of nesting habitat by coastal construction, environmental contaminants and increased human presence are viewed as the major problems to recovery of green and hawksbill turtle populations. Beach mining and beach erosion are also detrimental because the islands of American Samoa have very few beaches suitable for turtle nesting habitat. American Samoa's human population is one of the fastest growing of the Pacific Islands (Pacific Sea Turtle Recovery Team, 1998a,b) and the people of the Samoan archipelago have traditionally harvested sea turtles for food and the shell. It is not known if pelagic fisheries affect sea turtles in American Samoa. Based on recent surveys, the total number of nesting female sea turtles (hawksbill and green turtle species combined) is estimated to be approximately 120 (Utzurrum 2002). A recent voluntary observer program on American Samoa-based longline vessels did not see any interactions with sea turtles on 76 observed longline sets during 2002.

Green sea turtle: As discussed in Section 3.4, the life cycle of the green sea turtle involves a series of long-distance migrations back and forth between their feeding and nesting areas (Craig 2002). In American Samoa, their only nesting area is at Rose Atoll. When they finish laying their eggs there, the green turtles leave Rose Atoll and migrate to their feeding grounds somewhere else in the South Pacific. After several years, the turtles will return to Rose Atoll to nest again. Every turtle returns to the same nesting and feeding areas throughout its life but that does not necessarily mean that all turtles nesting at Rose Atoll will migrate to exactly the same feeding area

Two green turtles with tagged flippers and three that were telemetered by satellite after nesting at Rose Atoll were recovered in Fiji (Balazs et al. 1994). In addition, a green turtle with tagged flippers from Rose Atoll was found dead in Vanuatu less than one year later (G.H. Balaz cited in Grant et al. 1997).

Hawksbill sea turtle: Hawksbill turtles are most commonly found at Tutuila and the Manu'a Islands, and are also known to nest at Rose Atoll and Swains Island (Utzurrum 2002).

Leatherback sea turtle: In 1993, the crew of an American Samoa government vessel engaged in experimental longline fishing, pulled up a small freshly dead leatherback turtle about 5.6 km south of Swains Island. This is the first leatherback turtle seen by the vessel's captain in 32 years of fishing in the waters of American Samoa. The nearest known leatherback nesting area to the Samoan archipelago is the Solomon Islands (Grant 1994).

Olive ridley sea turtle: Olive ridley turtles are uncommon in American Samoa, although there have been at least three sightings. Necropsy of one recovered dead olive ridley found that it was injured by a shark, and may have recently laid eggs, indicating that there may be a nesting beach in American Samoa (Utzurrum 2002).

Loggerhead sea turtle: There are no reports of loggerheads turtles in American Samoa.

Marine Mammals

In Fagatele Bay National Marine Sanctuary, southern Pacific humpback whales mate and calve from June through September. Sperm whales are occasionally seen in the Sanctuary and around Tutuila as well. Several species of dolphins also frequent the Sanctuary waters (WPRFMC 2000). In addition, there is anecdotal evidence that pilot whales occasionally steal bait and fish from American Samoa-based longline gear. There are no pinnepeds known to occur in American Samoa.

Seabirds

Table 20 presents the seabirds found in American Samoa. Twelve species of migratory seabirds reside on Rose Atoll, one of which is the bristle-thighed curlew, listed as "vulnerable" under the ESA.

Table 20: Seabirds Known to be Present Around American Samoa

Common Name	Scientific Name
Resident seabirds (i.e., breeding):	
Wedge-tailed Shearwaters	*Puffinus pacificus*
Audubon's Shearwater	*Puffinus lherminieri*
Christmas Shearwater	*Puffinus nativitatis*
Tahiti Petrel	*Pseudobulweria rostrata*
Herald Petrel	*Pterodroma heraldica*
Collared Petrel	*Pterodroma brevipes*
Red-footed Booby	*Sula Sula*
Brown Booby	*Sula leucogaster*
Masked Booby	*Sula dactylatra*
White-tailed Tropicbird	*Phaethon lepturus*
Red-tailed Tropicbird	*Phaethon rubricauda*
Great Frigatebird	*Fregata minor*
Lesser Frigatebird	*Fregata ariel*
Sooty Tern	*Sterna fuscata*
Brown Noddy	*Anous stolidus*
Black Noddy	*Anous minutus*
Blue-gray Noddy	*Procelsterna cerulea*
Common Fairy-Tern (White Tern)	*Gygis alba*
Visitors/vagrants:	
Short-tailed Shearwater	*Puffinus tenuirostris*
Mottled Petrel	*Pterodroma inexpectata*
Phoenix Petrel	*Pterodroma alba*
White-bellied Storm Petrel	*Fregetta grallaria*
Polynesian Storm Petrel (Pratt - resident)	*Nesofregetta fuliginosa*
Laughing Gull	*Larus atricilla*

Black-naped Tern	*Sterna sumatrana*

3.5.1.3 Fisheries

Under the authority of the MSA, the Council established (approved Secretary of Commerce) approved thresholds to determine for overfishing (fishing mortality) and overfished (stock biomass) conditions for fisheries of the Western Pacific Region. Currently, no fishery in American Samoa has been determined to be experiencing overfishing or to be overfished.

3.5.1.3.1 Dermersal Fisheries

Coral Reef: Coral reef fishes and invertebrates are harvested in American Samoa by various gear types including hook and line, spear gun, and gillnets. Approximately 25,000 lbs of coral reef species were reported landed by domestic commercial fisheries in 2003 (NMFS 2004) Resources such as giant clams, parrot fish, surgeonfish, and jacks are believed low abundance levels (Craig et al. 2005).

Crustaceans: In American Samoa, lobsters are more expensive sea-foods than fishes, but are often present in important meals such as wedding, funerals, Christmas, or New Years day. Formerly, lobsters were provided at the level of the village/family, whereas nowadays, they are mainly bought at the market, caught by professional/regular fishermen. Spiny lobster (*Panulirus penicillatus)* is the main species speared by night near the outer slope by free divers while diving for finfish. Total landings expanded from a market survey are estimated to average 1,271 lbs of spiny lobsters sold per year (without taking subsistence and recreational catches into account) (Couture 2003).

Bottomfish: Long before the arrival of Europeans in the islands of Samoa the indigenous people of those islands had developed specialized techniques for catching bottomfish from canoes. Some bottomfish, such as *ulua*, held a particular social significance and were reserved for the *matai* (chiefs) (Severance and Franco 1989).

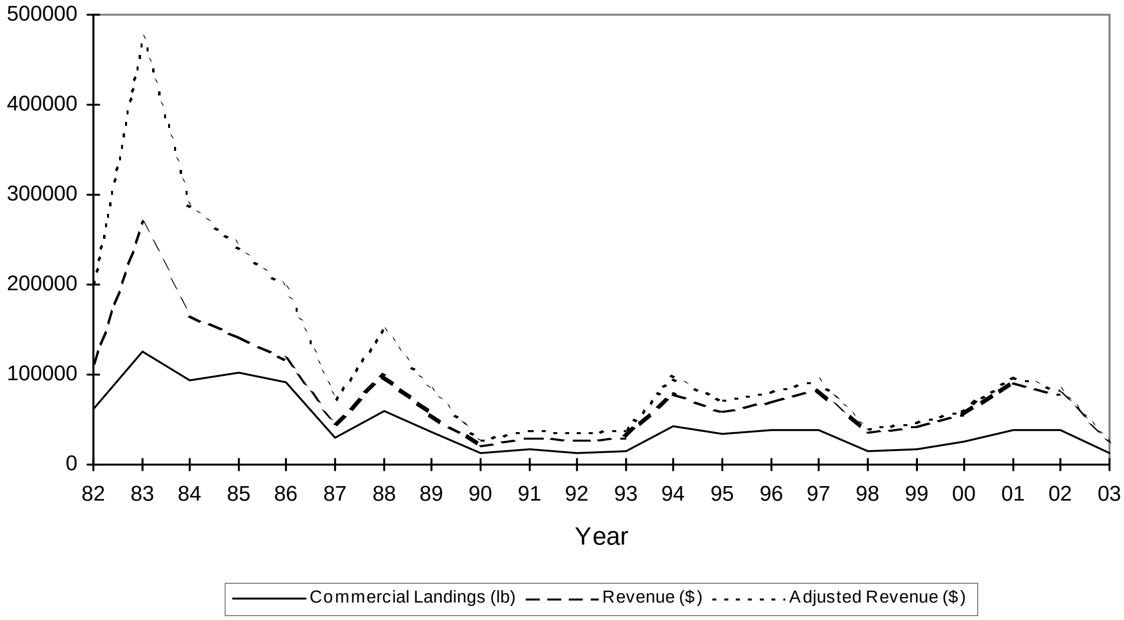
By the 1950s, many of the small boats in American Samoa were equipped with outboard engines, steel hooks were used instead of ones made of pearl shell, and monofilament fishing lines had replaced hand woven sennit lines. However, bottomfish fishing remained largely a subsistence practice. It was not until the early 1970s that the bottomfish fishery developed into a commercial venture (Ralston 1979). Surveys conducted around Tutuila Island from 1967 to 1970 by the American Samoa Office of Marine Resources indicated that the potential existed for developing a small-scale commercial bottomfish fishery. Four major fishing grounds were identified around the island of Tutuila: Taputapu, Matatula, Leone West Banks and Steps Point (Severance and Franco 1989). In 1972, a government-subsidized boat building program was initiated to provide local fishermen with gasoline and diesel powered 24 ft wooden dories capable of fishing for bottomfish in offshore waters. Twenty-three boats were eventually built and used by fishermen. By 1980, however, mechanical problems and other difficulties had reduced the dory fleet to a single vessel (Itano 1996).

In the early 1980s, the 28-ft FAO-designed *alia* catamaran was introduced into American Samoa, and local boat builders began constructing these inexpensive but seaworthy fishing vessels. A recovery in the size of the fishing fleet, together with a government-subsidized development project aimed at exporting deep-water snapper to Hawaii, caused another notable increase in bottomfish landings (Itano 1996). Between 1982 and 1988, the bottomfish fishery comprised as much as half of the total catch of the local commercial fishery. However, since 1988, the nature of American Samoa's fisheries has changed dramatically, with a shift in importance from bottomfish fishing to trolling and longlining for pelagic species (WPRFMC 1999). Landings trends in the bottomfish fishery have also been periodically adversely impacted by hurricanes. The 1987 hurricane, in particular, damaged or destroyed a large segment of American Samoa's small boat fishing fleet.

Today, the bottomfish fishery of American Samoa consists of approximately 19 part-time vessels that typically jig overnight using skipjack tuna as bait (WPRFMC 2004). The fishing technology employed by the fleet continues to be relatively unsophisticated. Most vessels are aluminum "alia" catamarans less than 30 ft length and many of the boats are outfitted with wooden hand reels that are used for both trolling and bottomfish fishing. In 1999, less than 10 percent of the boats carry a depth recorder, electronic fish finder or global positioning system (Severance et al. 1999). Because few boats carry ice, they typically fish within twenty miles of shore. In recent years, however, a growing number of fishermen in American Samoa have been acquiring larger (>35 ft) vessels with capacity for chilling or freezing fish and a much greater fishing range.

In recent years, commercial landings of bottomfish accounted for almost all of the total bottomfish catch. The amount of bottomfish caught for recreational or subsistence purposes was very small. In 2002, there were no recreational or charter landings recorded. The commercial catch declined significantly in 1987, recovered slightly in 1988, but then decreased dramatically again during the early 1990s (Figure 9). The overall decline was due to the effects of hurricanes that struck the territory in 1987, 1990, and 1991, the departure of several highliners from the fishery and a shift by the fleet from bottomfish fishing to trolling for pelagic species (WPRFMC 1999). In addition, fishermen began to experience competition in local markets from fresh bottomfish imported from Samoa and Tonga. In 1991, bottomfish imports exceeded local landings of bottomfish. The significantly greater 1994 total landings, when compared to previous years, occurred primarily because of improved catch recording, an increase in effort by highline vessels and a high fish demand for government and cultural events. However, the 1998 harvest was only 25% of the 17-year average and was the smallest catch since 1992. This decline was primarily due to a shift by highliners in the local fleet from bottomfish fishing to fishing for pelagic species with longline gear. Since 1998 some alias have returned to bottomfish fishing when longline catches and prices for pelagic species declined. In 2003, 19 vessels took 291 trips and landed 26,200 lbs of bottomfish in American Samoa. Of this, 2,5509 lbs were sold for total ex-vessel revenue of $25,012 (WPRFMC 2004). The majority of the catch is emperors and snappers. Figure 10 provides historical data on commercial bottomfish harvests in American Samoa.

Figure 9: Bottomfish Landings and Value in American Samoa 1982-2003
(Source: WPRFMC 2004)

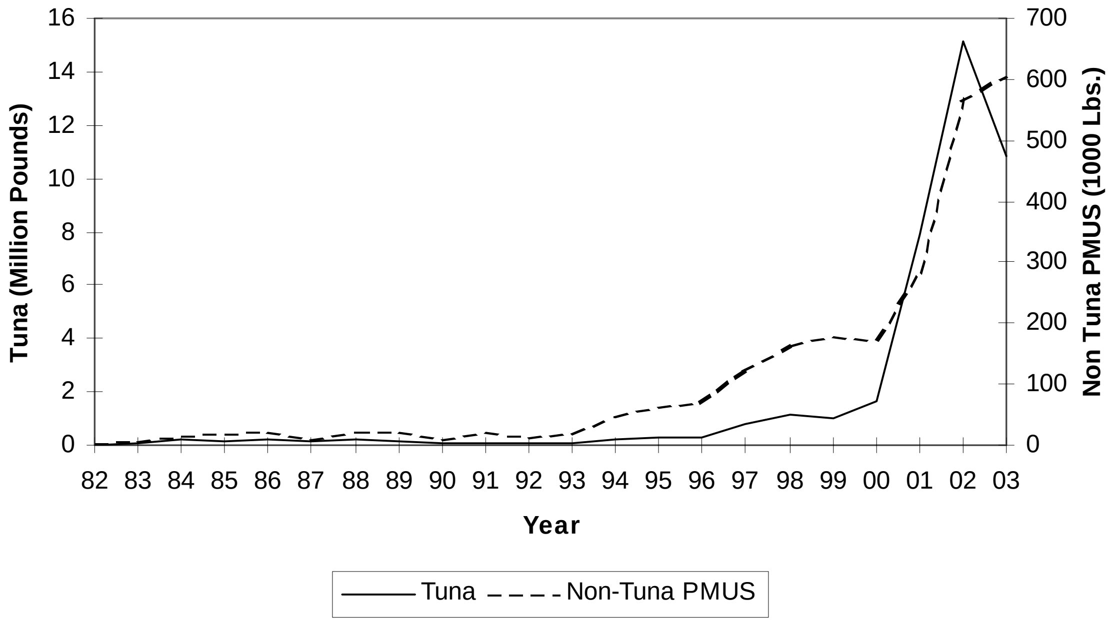


Precious Corals: There are is no known precious coral beds or precious coral fisheries in American Samoa.

3.5.1.3.2 Pelagic Fisheries

The harvest of pelagic fish has been a part of the way of life in the Samoan archipelago since the islands were first settled some 3,500 years ago (Severance and Franco 1989). Subsistence fishing continues to the present but the importance of pelagic fisheries as a source of income and employment is increasing. Commercial ventures are diverse, ranging from small-scale vessels having very limited range to large-scale vessels catching tuna in the EEZ and distant waters and delivering their catches to canneries based in American Samoa. Total pelagic landings by American Samoa-based longline, troll, and handline vessels were approximately 11 million pounds in 2003 (Figure 10) with longline landings comprising nearly 99% of this total (WPFMC 2004). During 2003, nearly 90% of these longline landings were albacore, with yellowfin, bigeye and skipjack tuna making up the majority of the remainder (WPFMC 2004).

Figure 10: Tuna and Non-Tuna PMUS Landings in American Samoa 1982-2003
(Source: WPRFMC 2004)



Small-scale longline: Most participants in the small-scale domestic longline fishery are indigenous American Samoans with vessels under 50 ft in length, most of which are alia boats under 40 ft in length. The stimulus for American Samoa's commercial fishermen to shift from troll or handline gear to longline gear in the mid-1990s (see Figure 10) was the fishing success of 28' alia catamarans that engaged in longline fishing in the EEZ around Independent Samoa. Following this example, the fishermen in American Samoa deploy a short monofilament longline, with an average of 350 hooks per set, from a hand-powered reel (WPRFMC, 2000). An estimated 90 percent of the crews working in the American Samoa small-scale alia longline fleet are believed to be from Independent Samoa. The predominant catch is albacore tuna, which is marketed to the local tuna canneries (DMWR 2001).

***Large-scale longline*:** American Samoa's domestic longline fishery expanded rapidly in 2001. Much of the recent (and anticipated future) growth is due to the entry of monohull vessels larger than 50 ft in length. The number of permitted longline vessels in this sector increased from three in 2000 to 30 by March 21, 2002 (DMWR, unpubl. data). Of these, five permits (33 percent of the vessel size class) for vessels between 50.1 ft - 70 ft and five permits (33 percent of the vessel size class) for vessels larger than 70 ft were believed to be held by indigenous American Samoans as of March 21, 2002 (T. Beeching, DMWR, pers. comm to P. Bartram, March 2002). Economic barriers have prevented more substantial indigenous participation in the large-scale sector of the longline fishery. The lack of capital appears to be the primary constraint to substantial indigenous participation in this sector (DMWR 2001).

While the smallest (less than or equal to 40 ft) vessels average 350 hooks per set, a vessel over 50 ft can set 5-6 times more hooks and has a greater fishing range and capacity for storing fish (8-40 mt as compared to 0.5-2 mt on a small-scale vessel). Larger vessels are also outfitted with hydraulically-powered reels to set and haul mainline, and modern electronic equipment for navigation, communications and fish finding. Most are presently being operated to freeze albacore onboard, rather than to land chilled fish. Three vessels that left Hawaii after the swordfish longline fishery closure are operating in the American Samoa tuna longline fishery under new ownership. It does not appear that large numbers of longliners from Hawaii are relocated in American Samoa. Instead, large vessels have participated in the American Samoa longline fishery from diverse ports and fisheries, including the US west coast (6), Gulf of Mexico (3), and foreign countries (4 now under U.S. ownership) (O'Malley and Pooley, 2002).

Distant-water purse seine fishery: The US purse seine fleet operating in the central and western Pacific uses large nets to capture skipjack, yellowfin and bigeye tuna near the ocean surface, in free-swimming schools and around fish aggregation devices (FADs) deployed by the fleet. These vessels often land their catches at canneries based in American Samoa. These large vessels (200-250 ft length) could not be economically operated for longline fishing but some former participants in the U.S. purse seine fishery have acquired more suitable vessels and participated in the American Samoa-based longline fishery (NMFS 2001

Distant-water jig albacore fishery: Domestic albacore jig vessels also supply tuna to the canneries in American Samoa. Since 1985, about 50-60 US vessels have participated in the high-seas troll fishery for albacore. This fishery occurs seasonally (December through April) in international waters at 35°-40° S latitude. The vessels range in length from 50 to 120 feet, with the average length about 75 feet (Heikkila 2001). They operate with crews of 3-5 and are capable of freezing 45-90 tons of fish (WPRFMC 2000).

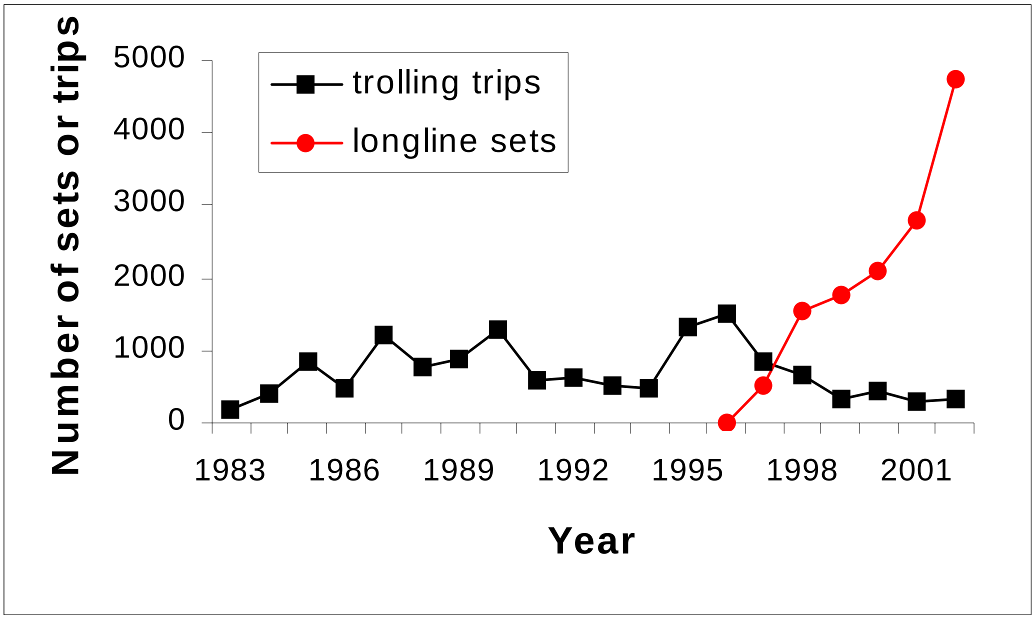
Troll and handline fishery: From October 1985 to the present, catch and effort data in American Samoa fisheries have been collected through a creel survey that includes subsistence and recreational fishing, as well as commercial fishing. However, differentiating commercial troll fishing activity from non-commercial activity can be difficult.

Recreational fishing purely for sport or pleasure is uncommon in American Samoa. Most fishermen normally harvest pelagic species for subsistence or commercial sale. However tournament fishing for pelagic species began in American Samoa in the 1980s, and between 1974 and 1998, a total of 64 fishing tournaments were held in American Samoa (Tulafono 2001). Most of the boats that participated were alia catamarans and small skiffs. Catches from tournaments are often sold, as most of the entrants are local small-scale commercial fishermen. In 1996, three days of tournament fishing contributed about one percent of the total domestic landings. Typically, 7 to 14 local boats carrying 55 to 70 fishermen participated in each tournament, which were held 2 to 5 times per year (Craig et al. 1993).

The majority of tournament participants have operated 28-foot alia, the same vessels that engage in the small-scale longline fishery. With more emphasis on commercial longline fishing since 1996, interest in the tournaments has waned (Tulafono 2001) and pelagic fishing effort has shifted markedly from trolling to longling (see Figure 11). Catch and release recreational fishing is virtually unknown in American Samoa. Landing fish to meet cultural obligations is so important that releasing fish would generally be considered a failure to meet these obligations

(Tulafono 2001). Nevertheless, some pelagic fishermen who fish for subsistence release fish that are surplus to their subsistence needs (S. Steffany, pers. comm. to Paul Bartram, Sept. 15, 2001).

Figure 11: Distribution of Pelagic Effort Between Trolling and Longlining in American Samoa
(Source: WPRFMC 2003)



American Samoa has been unable to develop a significant tourist industry that could support charter fishing (Territorial Planning Commission/Dept. of Commerce, 2000). Nor is American Samoa known for producing large game fish. Few, if any, charter boats are in operation (Tulafono 2001), so no data are collected specifically for the charter fishing sector.

3.5.1.4 Communities

American Samoan dependence on fishing undoubtedly goes back as far as the peopled history of the islands of the Samoan archipelago, about 3,500 years ago (Severance and Franco 1989). Many aspects of the culture have changed in contemporary times but American Samoans have retained a traditional social system that continues to strongly influence and depend upon the culture of fishing. Centered around an extended family (`aiga) and allegiance to a hierarchy of chiefs (matai), this system is rooted in the economics and politics of communally-held village land. It has effectively resisted Euro-American colonial influence and has contributed to a contemporary cultural resiliency unique in the Pacific islands region (Severance et al. 1999).

From the time of the Deeds of Cession to the present, despite increasing western influences on American Samoa, American Samoans native have expressed a very strong preference for and commitment to the preservation of their traditional matai (chief), aiga (extended family) and communal land system, which provides for social continuity, structure and order. The traditional system is ancient and complex, containing nuances that are not well understood by outsiders (TPC/Dept. of Commerce, 2000).

Traditional American Samoan values still exert a strong influence on when and why people fish, how they distribute their catch and the meaning of fish within the society. When distributed, fish and other resources move through a complex and culturally embedded exchange system that supports the food needs of `aiga, as well as the status of both matai and village ministers (Severance et al. 1999).

Under the MSA, the islands of American Samoa are recognized as a fishing community. However, American Samoa's history, culture, geography and relationship with the U.S. are vastly different from those of the typical community in the continental U.S. and are closely related to the heritage, traditions and culture of neighboring independent Samoa. The seven islands that comprise American Samoa were ceded in 1900 and 1904 to the United States and governed by the U.S. Navy until 1951, when administration was passed to the US Department of the Interior, which continues to provide technical assistance, represent territorial views to the Federal government and oversee Federal expenditures and operations. American Samoa elected its first governor in 1978 and is represented by a non-voting member of Congress.

Tutuila, American Samoa's largest island, is the center of government and business and is home to 90 percent of the estimated 63,000 total population of the territory. American Samoan natives born in the Territory are classified as US nationals and categorized as native Americans by the US government (TPC/Dept. of Commerce, 2000). Population density is about 320 people/km^2 and the annual population growth rate is nearly three percent, with projected population doubling time only 24 years. The net migration rate from American Samoa was estimated as 3.75 migrants/1,000 population in the year 2000 (CIA World Factbook).

The only U.S. territory south of the equator, American Samoa is considered "unincorporated" because the US Constitution does not apply in full even though it is under US sovereignty (TPC/Dept. of Commerce 2000). American Samoa's vision for the future is not fundamentally different from that of any other people in the U.S. but American Samoa has additional objectives that are related to its covenant with the U.S., its own constitution and its distinctive culture (Territorial Planning Commission/Dept. of Commerce, 2000). A central premise of ceding eastern Samoa to the U.S. was to preserve the rights and property of the islands' inhabitants. American Samoa's constitution makes it government policy to protect persons of American Samoan ancestry from the alienation of their lands and the destruction of the Samoan way of life and language. It provides for such protective legislation and encourages business enterprise among persons of American Samoan ancestry (Territorial Planning Commission//Dept. of Commerce 2000).

American Samoa has a small developing economy, dependent mainly on two primary income sources: the American Samoa Government, which receives income and capital subsidies from the Federal government, and the two fish canneries on Tutuila (BOH 2002). These two primary income sources have given rise to a third: a services sector that derives from and complements the first two. In 1993, the latest year for which the ASG has compiled detailed labor force and employment data, the ASG employed 4,355 persons (32.2 percent of total employment), followed by the two canneries with 3,977 persons (29.4 percent) and the rest of the services economy with 5,211 persons (38.4 percent). As of 2000, there were 17,644 people 16 years and older in the labor force, of which 16,718, or 95%, were employed (American Samoa Census 2000).

A large proportion of the territory's work force is from Western Samoa (now officially called Samoa) (BOH 2000). While it would be true to say that Western Samoans working in the territory are legally alien workers, in fact they are the same people, by culture, history, and family ties.

Statistics on household income indicate that the majority of American Samoans live in poverty according to U.S. income standards. American Samoa has the lowest gross domestic product and highest donor aid per capita among the U.S.-flag Pacific islands (Adams et al. 1999). However, by some regional measures American Samoa is not a poor economy. It's estimated per capita income of $4,357 (Census 2000) is almost twice the average for all Pacific island economies, although it is less than half of the per capita income in Guam, where proximity to Asia has led to development of a large tourism sector. Sixty-one percent of the population in 1999 was at or below poverty level (Census 2000).

The excellent harbor at Pago Pago and certain special provisions of U.S. law form the basis of American Samoa's largest private industry, fish processing, which is now more than forty years old (BOH 1997). The territory is exempt from the Nicholson Act, which prohibits foreign ships from landing their catches in U.S. ports. American Samoan products with less than 50 percent market value from foreign sources enter the United States duty free (Headnote 3(a) of the U.S. Tariff Schedule). The parent companies of American Samoa's fish processing plants enjoy special tax benefits, and wages in the territory are set not by Federal law but by recommendation of a special U.S. Department of Labor committee that reviews economic conditions every two years and establishes minimum wages by industry.

The ASG has estimated that the tuna processing industry directly and indirectly generates about 15 percent of current money wages, 10 to 12 percent of aggregate household income and 7 percent of government receipts in the territory (BOH 2000). On the other hand, both tuna canneries in American Samoa are tied to multinational corporations that supply virtually everything but unskilled labor, shipping services and infrastructure facilities (Schug and Galeai 1987). Even a substantial portion of the raw tuna processed by Star-Kist Samoa is landed by vessels owned by the parent company. The result is that few backward linkages have developed, and the fish-processing facilities exist essentially as industrial enclaves. Furthermore, most of the unskilled labor of the canneries is imported. Up to 90 percent of cannery jobs are filled by foreign nationals from Western Samoa and Tonga. The result is that much of the payroll of the canneries "leaks" out of the territory in the form of overseas remittances.

Harsh working conditions, low wages and long fishing trips have discouraged American Samoans from working on foreign longline vessels delivering tuna to the canneries. American Samoans prefer employment on the U.S. purse seine vessels, but the capital-intensive nature of purse seine operations limits the number of job opportunities for locals in that sector as well. However, the presence of the industrial tuna fishing fleet has had a positive economic effect on the local economy as a whole. Ancillary businesses involved in reprovisioning the fishing fleet generate a significant number of jobs and amount of income for local residents. Fleet expenditures for fuel, provisions and repairs in 1994 were estimated to be between $45 million and $92 million (Hamnett and Pintz 1996).

The tuna processing industry has had a mixed effect on the commercial fishing activities undertaken by American Samoans. The canneries often buy fish from the small-scale domestic longline fleet based in American Samoa, although the quantity of this fish is insignificant compared to cannery deliveries by the U.S. purse seine, U.S. albacore and foreign longline fleets. The ready market provided by the canneries is attractive to the small boat fleet, and virtually all of the albacore caught by the domestic longline fishery is sold to the canneries. Nevertheless, local fishermen have long complained that a portion of the frozen fish landed by foreign longline vessels enters the American Samoa restaurant and home-consumption market, creating an oversupply and depressing the prices for fresh fish sold by local fishermen.

Local fishermen have indicated an interest in participating in the far more lucrative overseas market for fresh fish. To date, however, inadequate shore-side ice and cold storage facilities in American Samoa and infrequent and expensive air transportation links have been restrictive factors.

Using information obtained from industry sources for a presentation to the American Samoa Legislature (Faleomavaega 2002), canning the 3,100 mt of albacore landed in American Samoa by the domestic longline fishery in 2001 is estimated to have generated 75 jobs, $420,000 in wages, $5 million in processing revenue and $1.4 million in direct cannery spending in the local economy. Ancillary businesses associated with the tuna canning industry also contribute significantly to American Samoa's economy. The American Samoa government calculates that the canneries represent, directly and indirectly, from 10% - 12% of aggregate household income, 7% of government receipts and 20% of power sales (BOH 2000).

American Samoa's position in the industry is being eroded by forces at work in the world economy and in the tuna canning industry itself. Whereas wage levels in American Samoa are well below those of the US, they are considerably higher than in other canned tuna production centers around the world. To remain competitive, U.S. tuna producers are purchasing more raw materials, especially pre-cooked loins, from foreign manufacturers. Tax benefits to US canneries operating in American Samoa have also been tempered in recent years by the removal of a provision in the US tax code that previously permitted the tax-free repatriation of corporate income in US territories. Trends in world trade, specifically reductions in tariffs, are reducing the competitive advantage of American Samoa's duty-free access to the US canned tuna market (Territorial Planning Commission/Dept. of Commerce, 2000).

Despite the long history of the tuna canning industry in American Samoa, processing and marketing of pelagic fish by local enterprises has not yet developed beyond a few, short-term pilot projects. However, the government's comprehensive economic development strategy (Territorial Planning Commission/Dept. of Commerce, 2000) places a high priority on establishing a private sector fish processing and export operation proposed to be located at the Tafuna Industrial Park.

3.5.2 Commonwealth of Northern Mariana Islands

Located between 13° and 20° N, the Commonwealth of the Northern Mariana Islands (CNMI) encompasses 14 islands and many banks stretching over 400 nm (760 km) in a north-south direction. The total land area of all 14 islands is approximately 477 km². Within the EEZ and approximately 120 nm west of the island chain, is the West Mariana Ridge; a line of seamounts running parallel to the main islands. The islands north of Saipan are called the northern islands, which have been designated as wildlife conservation areas. Seamounts near the Northern Islands include Bank A, Pathfinder Reef, Bank D, Bank C and Arakane Reef. The islands classified as geologically "older" are raised limestone southern islands and include Rota, Aguijan, Tinian, Saipan, and Farallon de Medinilla (FDM) whereas the "younger" and still volcanically active islands include Anatahan, Sarigan, Guguan, Alamagan, Pagan, Agrihan, Asuncion, Maug and Farallon de Pajaros. Over 99.5% of the population occurs on the southern islands of Saipan, Tinian and Rota, with 89% living on Saipan (Census 2000). Aguijan is the only uninhabited southern island.

CNMI's climate can be considered tropical (i.e. Saipan) and subtropical (i.e. Maug), however average air temperatures are consistently around 80° F. Prevailing winds in CNMI are northeasterly trade winds with averaging near 10 knots, however southeasterly winds are observed in summer months and west and northwesterly winds are observed during winter months. Average annual rainfall in the southern islands and northern islands is around 82 inches and 75 inches, respectively. Due their position in the western Pacific, typhoons in the vicinity of the Mariana Archipelago occur almost every year (Eldredge 1983).

3.5.2.1 Marine Environment

Coral Reefs

The total coral reef area in CNMI is 124 km² (within the 10 fm curve) and 476 km² (within the 100 fm curve) (Rohnman et al. in press). The older, southern islands have fringing and/or barrier reefs, while the volcanically active, northern islands have relatively little coral reef (Eldredge1983).

The southern islands support a variety of marine habitat types. Saipan's potential coral reef area within the 10 fm contour is 58 km² and includes fringing reefs, inshore and offshore patch reefs, and a well-developed barrier reef-lagoon system along most of the leeward coast (Eldredge 1983, Gourley 1997, Rohnman et al. in press). Saipan Lagoon also comprises some large areas of well-developed seagrass beds, as well as a small area of mangroves (Gourley 1997).

The corals reefs within the 10 fm curve of Rota (12 km²), Tinian and Agrijan (18 km²) are less well developed than those on Saipan, and are generally restricted to small fringing reef systems (Eldredge 1983, Gourley 1997, Rohnmann et al. 2003). A study of the reefs adjacent to beaches on Tinian reported that coral reefs are present around much of the island and, in general, reefs on the eastern (leeward) coastline are better developed and have greater species diversity than those on the western coast (PSDA 1997). Rota also has some well developed reefs, especially in

Sasanhaya Bay on the south side, and some offshore reefs on the north and west sides of the island (PSDA 1997).

Farallon de Medinilla (FDM) is an uninhabited island with 2 km^2 of potential coral reef area within the 10 fm curve (Rohnman et al. in press). The island has been used as a military bombardment range for the last 30 plus years (Eldredge 1983, PSDA 1997, Starmer et al. 2005). There is no fringing reef or shallow coastal zone at FDM, since deepwater surrounds much of the island and the submarine slope appear to be very steep (PSDA 1997). The combination of this vertical profile and wave action on the windward side of the island probably explains the limited coral reef biota in shallow water on that side (PSDA 1997). As such, marine resources are mostly concentrated on the leeward side of the island, where the substrate drops gradually seaward (PSDA 1997). Farallon de Medinilla is near a large shallow bank a mile north of the island (about 18 m deep: PSDA 1997), which is an extensive coral reef area (Hunter 1995).

The northern islands are relatively young (1-1.5 million years) and include active volcanoes on the islands of Pagan (erupted in 1981), Anatahan (erupted in 2003), Guguan, Asuncion, Agrihan and Uracas (Asakura et al. 1994a, Sturman et al 2005). In general, reef development is poor or non-existent on the Northern Islands (Eldredge 1983) with Pagan having the greatest area of potential coral reef area at 11 km^2 with the 10 fm curve (Rohman et al. 2005). Most of the reefs that do exist tend to be narrow, rocky reefs on steep slopes, with coral communities growing on volcanic substrata and little true coral reef development (Eldredge et al. 1977a, Eldredge 1983, Donaldson 1995, Birkeland 1997b). However there are a few small "embryonic" or "apron" reefs on these islands, which may have some reef formation but do not reach sea level (Birkeland 1997b). These include areas at depths of >25m at western Anatahan, southern Sarigan, and parts of Pagan (Donaldson et al. 1994, Donaldson 1995). Eldredge et al. (1977a) also reported a well-developed fringing reef on the west side of Maug.

These differences in the development of reefs throughout the Marianas appears to be related to the age and geology of the islands, since coral growth is just as vigorous in both the north and south (Birkeland 1997b). For example, geological faulting of large areas in the older Southern Marianas (e.g. west coast of Saipan), have created large, oblique, shallow-water surfaces, which have supported extensive reef growth and the development of reef flats and lagoons over time (Birkeland 1997b). In contrast, the islands in the north are younger with quite vertical profiles, which do not provide the basis for extensive reef development (Birkeland 1997b).

Low to moderate numbers of starfish are believed to have been responsible for substantial coral mortality on some reefs around Saipan over the last two decades. This includes areas in Saipan Lagoon (Duenas & Swavely 1985, Richmond & Matson 1986), the Obyan-Naftan area (Randall et al. 1988), and Laulau Bay (PBEC 1984, Randall et al. 1991). However, the starfish do not appear to be abundant at present, and local divers report that starfish are only seen occasionally at the primary dive sites (e.g. Obyan and Laulau Bay: J. Comfort pers. comm.)

Starfish outbreaks have also been recorded on the other islands including occasional, small-scale outbreaks on Rota since the 1980s (Mark Michael pers. comm., CRM 1996). There have also been reports of starfish causing damage to reefs on the northern islands of CNMI, including Maug and Alamagan (Eldredge 1983).

CNMI's coral reefs have experienced some damage from the frequent typhoons in the area, and coral bleaching has occurred in 1994, 2001, and 2003. In addition, coral reefs in some locations appear to have been affected by human activities, including fishing, sedimentation and nutrient loading (Starmer et al. 2005).

Available information suggests that the current condition of the coral reefs in the southern islands of CNMI is quite variable (Starmer et al. 2005). Most appear to be in good condition, except in some heavily populated areas where the reefs have been degraded by human activities. The current focus for concern are the reefs in Saipan Lagoon, since this area encompasses nearly all of the Commonwealth's population, tourism industry, commercial activity, subsistence fishing, and water-oriented recreation (Duenas and Swavely 1985).

In general, it appears that the reefs in the Northern islands are also in good condition, because of their isolation from human population centers (Birkeland 1997b). The exceptions are localized areas that may have been affected by volcanic or military activities (e.g. Pagan and Farallon de Medinilla).

Deep Reef Slope, Banks, and Seamount Habitat

A total of 579 square km of banks and reefs has been estimated in the EEZ surrounding the CNMI (Hunter 1995). Of this area, 534 square km are outside 3 nm. The submerged seamounts 120 nm west of the emergent islands have been estimated to have a total of 50-60 square km² of viable habitat to support bottomfish populations (WPFMC 2005).

Pelagic Habitat

Generally, the major surface current affecting CNMI is the North Equatorial Current (see Figure 4), which flows westward through the islands, however the Subtropical Counter Current affects the Northern Islands and generally flows in a easterly direction (Elgredge 1983). Depending on the season, sea surface temperatures near the Northern Mariana Islands vary between 80.9° – 84.9° F. The mixed layer extends to between depths of 300-400 ft (Eldredge 1983).

3.5.2.2 Protected Species

Sea Turtles

Both green and hawksbill turtles are known to occur in waters around the CNMI (Kolinski et al. 1999).

***Green Sea Turtle*:** Based on nearshore surveys conducted jointly between the CNMI-DFW and the NMFS around the Southern Islands (Saipan-1999, Rota and Tinian-2001), an estimated 1,000 to 2,000 green sea turtles forage in these areas (Seman 2002). The green sea turtle is a traditional food of the native population and although harvesting them is illegal, divers have been known to take them at sea and others have taken the nesting females (NMFS & USFWS 1998a). Turtle eggs are also harvested in the CNMI. Nesting beaches and seagrass beds on Tinian and Rota are in good condition but beaches and seagrass beds on Saipan have been impacted by hotels, golf courses and general tourist activities.

Hawksbill Sea Turtle: Although hawksbill turtles have occasionally been sighted in the past around the CNMI they were not observed in a detailed assessment conducted in 1999, nor were they observed in 10 aquatic surveys along the shores of Tinian in 1995. According to the 1998 Pacific Sea Turtle Recovery Team Recovery Plan for the hawksbill turtle (NMFS & USFWS, 1998b), there are no reports of nesting in the CNMI. This does not rule out the possibility of a few hawksbill nests as nesting surveys on small pocket beaches in remote areas of CNMI have never been done. A single hawksbill sighting occurred in 1996 during the detonation of an unexploded ordinance off of Rota. The turtle was recovered near the explosion sight and subsequently died, apparently from internal injuries incurred from the blast (Trianni 1998c).

Marine Mammals

Cetaceans: Humpback whales (*Megaptera novaeangliae*) are known to appear between Saipan and FDM. Sightings of Risso's dolphin (*Grampus griseus*), Cuvier's beaked whale (*Xiphias cavirostris*), pygmy sperm whale (*Kogia breviceps*), pilot whale (*Globicephala melaena*), striped dolphin (*Stenella coeruleoalba*), and the pan-tropic whitebelly spinner dolphin (*Stenella longirostris longirostris*) have also occurred around CNMI.

Pinnipeds and Sirenians: No pinnipeds or sirenians species are known to occur in CNMI waters.

Seabirds

According to Pratt et al (1987), the following seabirds have been sighted and are considered residents of the CNMI; wedge-tailed shearwater (*Puffinus pacificus*), white-tailed tropicbird (*Phaethon lepturus*), red-tailed tropicbird (*Phaethon lepturus*), masked booby (*sula dactylatra*) and brown booby (*Sula leucogaster*).

The following seabirds have been sighted and are considered visitors to the CNMI; streaked shearwater (*Calonectris leucomelas*), short-tailed shearwater (*Puffinus tenuirostris*), Christmas shearwater (*Puffinus nativitatis*), Newell's shearwater (*Puffinus auricularis*), Audobon's shearwater (*Puffinus iherminieri*), Leach's storm-petral (*Oceanodroma leucorhoa*), Matsudaira's storm-petral (*Oceanodroma matsudairae*), and the red-footed booby (*Sula sula*). Of these, only the Newell's shearwater is listed as endangered. There have been no sightings of the endangered short-tailed albatross (*Diomedea albatrus*) in the CNMI although the CNMI is within the range of the only breeding colony at Tora Shima, Japan.

3.5.2.3 Fisheries

Under the authority of the MSA, the Council established (approved by Secretary of Commerce) thresholds to determine for overfishing (fishing mortality) and overfished (stock biomass) conditions for fisheries of the Western Pacific Region. Currently, no fishery in the CNMI has been determined by NMFS to be experiencing overfishing or to be overfished.

3.5.2.3.1 Demersal Fisheries

Coral Reef: Commercial landings of coral reef fish were approximately 136,000 lbs in 2003 (NMFS 2004) and include harvests of parrotfish, surgeonfish, goatfish, snappers, and emperors. Currently, a moratoriums exists on invertebrate coral reef fisheries targeting sea cucumber (*Actinopyga maruitiana*) and topshell (T*rochus niloticus*).Generally, coral reef fisheries in the CNMI are believed to be in good condition, but local depletion likely occurs in some areas of Saipan (Starmer et al. 2005).

Crustacean Fishery: Lobsters around the CNMI do not appear to go into traps and have not been found in waters deeper than 13 m (M. Trianni pers. comm). The CNMI fishery primarily targets spiny lobster in near-shore waters with reported catches taken almost exclusively within the 0-3 nm zone of the inhabited southern islands, generally on reef flats by scuba or free diving. Beyond 3 nm, the topography in most locations drops off steeply. These lobster habitats are relatively small and access is difficult. In the northern islands on reef surrounding FDM, bottomfish fishermen anchored for the night occasionally dive for lobsters (Trianni 1997b). Anchoring and diving at FDM occurs exclusively within 3 nm and most likely on the lee side within 100 yards of land. This activity is primarily for personal consumption. The directed commercial fishery is relatively small, with 493 lbs of commercial landings estimated for 2003 (NMFS 2004). However, unreported commercial and non-commercial catch could double this figure.

A second crustacean fishery undertaken in the 1990s trapped deep-water shrimp with fishing occurring on flat areas near steep banks at depths greater than 350 meters mostly on grounds around Saipan and Tinian (Ostazeski 1997). Two fishing companies began fishing for deep-water shrimp in May of 1994. While three species of pandalid shrimp are known to occur at varying depths in the waters around CNMI (*Heterocarpus ensifer* (366-550 m), *Heterocarpus laevigatus* (550-915 m) and *Heterocarpus longirostris* (>915 m), the most commercially valuable and subsequently targeted is the largest species, *Heterocarpus laevigatus* (Moffitt and Polovina 1987). Between May of 1994 and February of 1996, 12,160 kg of deep-water shrimp were landed. Of these, over 97% were *Heterocarpus laevigatus* with the remainder being *Heterocarpus ensifer*. Bycatch included a few deepwater eels *Synaphobranchus spp.*) and dogfish sharks. A large number of two species of Geryonid crabs were also caught. The crabs are a marketable incidental catch and could contribute to the success of any deep-water shrimp fishery. Strong currents, rough bottom topography and the fishing depth all contribute to the potential for gear loss, which has been experienced by this fishery in the past.

Throughout the Pacific, deep-water shrimp fisheries have been sporadic in nature (Hastie and Saunders 1992). The reasons for this are manifold. Gear loss has been a common problem and made many past ventures unprofitable. A second difficulty is the short shelf life and a history of inconsistent quality, leading to fluctuating market demand for the product. Lastly, these fisheries generally experience local depletion on known fishing grounds which leads to much lower catch rates. While other banks might have abundant stocks, unfamiliarity with them could lead to even greater gear loss. One of the CNMI ventures stopped fishing in June of 1995 after fishing a total of 193 days. The second venture began in December of 1995 and had fished 20 days by March of 1996 when non-CPD data collection ceased (Ostazesk 1997).

Shrimp trapping was conducted at 22 islands and banks during the NMFS RAIOMA cruises. Depth and area distribution were observed for the three major species of pandalid shrimp. Average size, size at maturity, reproductive cycles and sex ratios were analyzed and determined. Growth and mortality were also calculated. From analysis of catch per unit effort, determination of suitable habitat and the above parameters, total biomass and sustainable yield were calculated. Moffitt and Polovina (1987) estimated 676.6 tons of *Heterocarpus laevigatus* biomass and an exploitable sustainable yield of 162 tons per year for the combined EEZ waters around Guam and CNMI.

The DFW conducted a data collection project specifically for the deep-water shrimp fishery between May of 1994 and June of 1995. Catch and effort data was gathered for both types of traps, as well as bycatch data. Depth ranges for the fishery as well as depth of greatest abundance were recorded. Sex ratios and reproductive cycles were determined from 1,533 *H. laevigatus* examined (Ostazeski 1997). Research has also been conducted to create a depletion model which would estimate catch ability and would help determine the commercial viability of this fishery. It is likely that much shrimp went directly to an export market and was not caught by the CPD.

Bottomfish: The CNMI bottomfish fishery can be categorized into two segments: deep (>500 ft) and shallow (<500 feet) water fishing. The deep water fishery is primarily commercial, targeting snappers, the *Eteline* and *Pristipomoides* complexes, and the eight-banded grouper. The shallow water fishery, which targets the red-gilled emperor, is mostly commercial but also includes recreational and subsistence fishermen. Some trips last for more than a day, but the majority of bottomfishing trips by small vessels are one day.

The CNMI bottomfish fishery occurs primarily around the islands and banks from Rota Island to Zealandia Bank north of Sariguan. Historically, the CNMI has had a relatively small fishing fleet consisting primarily of small-scale local boats engaged in commercial, subsistence and recreational fishing. DFW has reported that 150 skiffs are used for subsistence fishing and 8 vessels ranging from 29 to 70 feet have been used commercially. However, the 2004 DFW "trip tickets" recorded a total of 43 vessels, both large and small, fishing commercially. The skiffs are generally less than 24 feet in length which restricts them to fishing one day trips during the daylight hours within a 30 mile radius of Saipan (WPRFMC 2003). Due to their distance from port, CNMI small boat fishermen are reluctant to fish western seamounts. Handlines, home fabricated hand reels and electric reels are commonly used for small-scale fishing operations.

Prior to 1994, large vessel ventures were short-lived. These vessels have landed as much as 70% of the total reported commercial bottomfish landings (M. Trianni, pers. comm.) The number of large-vessel commercial bottom-fishing ventures active in the Northern Islands increase to eight during 2000, but only four are presently active (WPRFMC 2005). Of these four, two primarily sell their catches on the island of Saipan (mostly to the large hotels in Tinian).

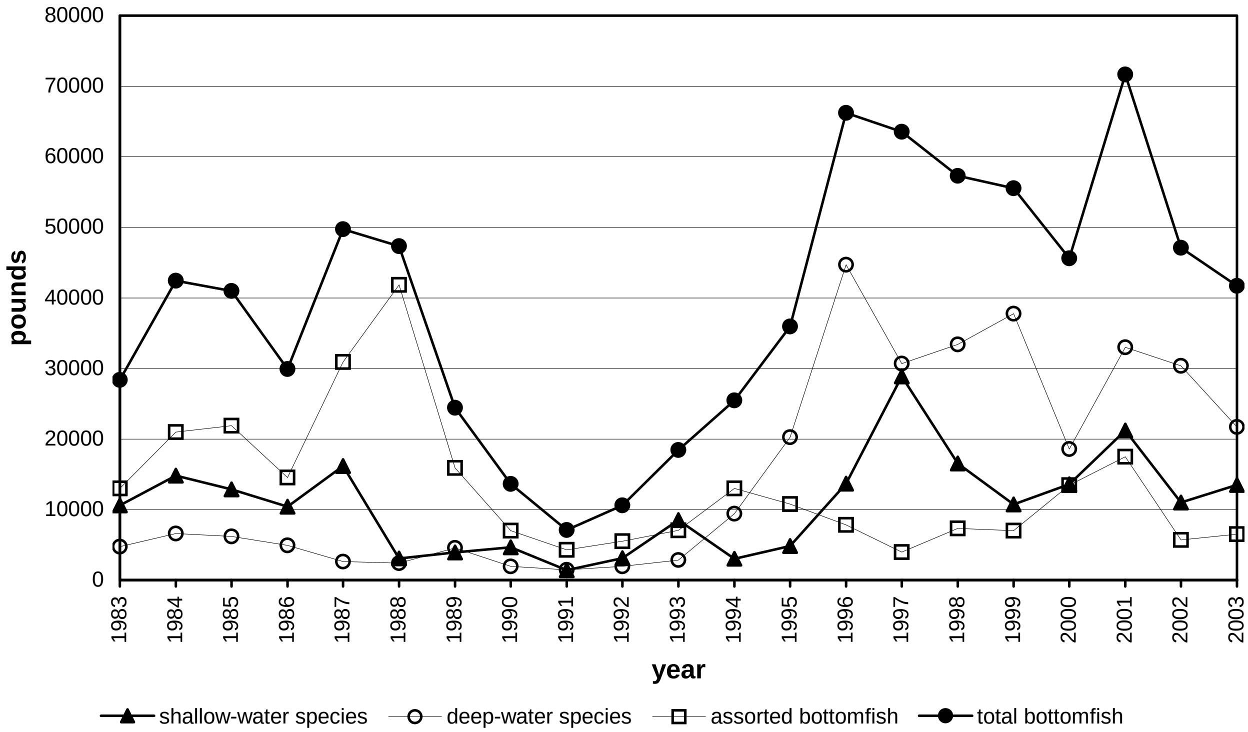
The larger commercial vessels are able to make multi-day trips to the Northern Islands, focusing their effort from Esmeralda Bank to Zealandia. Electric reels and hydraulics are the common gear used for these larger operations. No known commercial vessels have ice-making or freezer capabilities. Two ventures, comprised of three vessels, a 65-foot vessel and two 50-foot vessels, fished the Northern Islands deep-water complex in 1997, landing large volumes of onaga and eight-banded grouper.

By the end of 1999, two of the three bottomfishing vessels left the fishery. Four vessels have entered the fishery since late 2000, with two vessels occasionally targeting sharks (M. Trianni, pers. comm.).

Landings of bottomfish decreased in 2002 (34.3% fewer pounds in 2002 than in 2001) from the fishery's 2001 peak landings (see Figure 12). This fishery continues to show a high turnover with changes in the highliners participating in the fishery and an increased number of local fishermen focusing on reef fishes in preference to bottomfishes. Fishermen are also moving towards an increasing number of multi-purpose trips that focus primarily on reef fishes and catch pelagic species while in transit. In doing so, the shallow-water bottomfish complex continues to be exploited, but as part of the exploitation of reefs near the populated islands. Redgill emperor ("mafute") is the most frequently harvested and easily identified species in this complex, although a variety of snappers and groupers are also harvested (M.Trianni pers. comm.).

Over the last 6 years, 64% of mafute fishermen and 62% of onaga fishermen making commercial sales participated for only a single year and no fishermen participated in all 6 years (regardless of how small the sales) (WPFMC 2005). Fishermen utilizing larger vessels have greater access to the deep-water bottomfish resources, especially in the northern islands of the CNMI. However, this sector of the industry requires more investment, consistent long-term effort, and knowledge to recoup start-up costs than does the shallow-water bottomfish sector. This industry could continue to expand with support from a training program in bottomfishing that addresses the following: proper fish handling and maintenance of product quality, use of fathometers, nautical charts, modern electronic equipment such as GPS, fish finders, electric reels, anchoring techniques, marketing, and financial planning. Moreover, side-band sonar mapping of the banks used by commercial fishermen from Farallon de Medinilla to Rota should assist the growth of this sector (M.Trianni pers. comm.). It is estimated that in 2004 54,452 lbs of commercial landings of bottomfish were made, with a total ex-vessel value of $142,260 (WPRFMC 2004).

Figure 12: Bottomfish Landings in CNMI 1983-2003
(source: WPFMC 2005)



Gindai (*Pristopomoides zonatus*), yellowtail kalekale (*Pristopomoides auricilla*) and ehu (*Etelis carbunculus*) accounted for 79.1% of the total catch from all areas. The redgill emperor, *Lethrinus rubrioperculatus,* is specifically targeted and constitutes a large percentage of the total bottomfish catch for some of the areas. Research on the redgill emperor, including a tagging study, began in May of 1998. In addition, parameter estimations (e.g. CPUE, size structure and size at sexual maturity) for near-virgin populations are being determined in Guam with assistance from NMFS (D. Hamm, pers. comm.). This will help establish spawning potential ratio (the ratio of the current spawning stock to the spawning stock prior to fishing activity) for this important species. The data collection for this project is complete, the data are entered and analysis is in process. The study focused on a virgin bank, (Bank A) a highly-exploited bank (Galvez Bank) and a third semi-exploited bank (White Tuna Bank).

In 2000, CNMI's DFW produced a report on the life history of the red-gill emperor (Trianni 2000). A total of 5,730 fish were collected and analyzed between August 1997 and September 2000. Data was collected to determine CPUE, length-frequency, seasonality of spawning and size at maturity. Fish were measured and weighed and gonads were also weighed.

Precious Corals: Little is known about the presence of precious corals in the waters around the CNMI. The amount of habitat where precious corals can grow is limited throughout the archipelago because of the steep topography. Black coral grows in relatively shallow waters of

30-100 meters, while pink, gold and bamboo coral grows in deeper waters of 300 to1500 meters (Grigg 1993). Thus, precious corals could theoretically exist in both the near-shore waters (0-3 nm) as well as in the offshore (3-200 nm) waters.

Reports of a fishery from pre-World War II suggest that large quantities of high quality *Corallium spp.* were taken in waters north of Pagan Island (Takahashi 1942; as cited in Grigg and Eldredge 1975). Since then no known precious coral harvests have occurred within EEZ waters around CNMI.

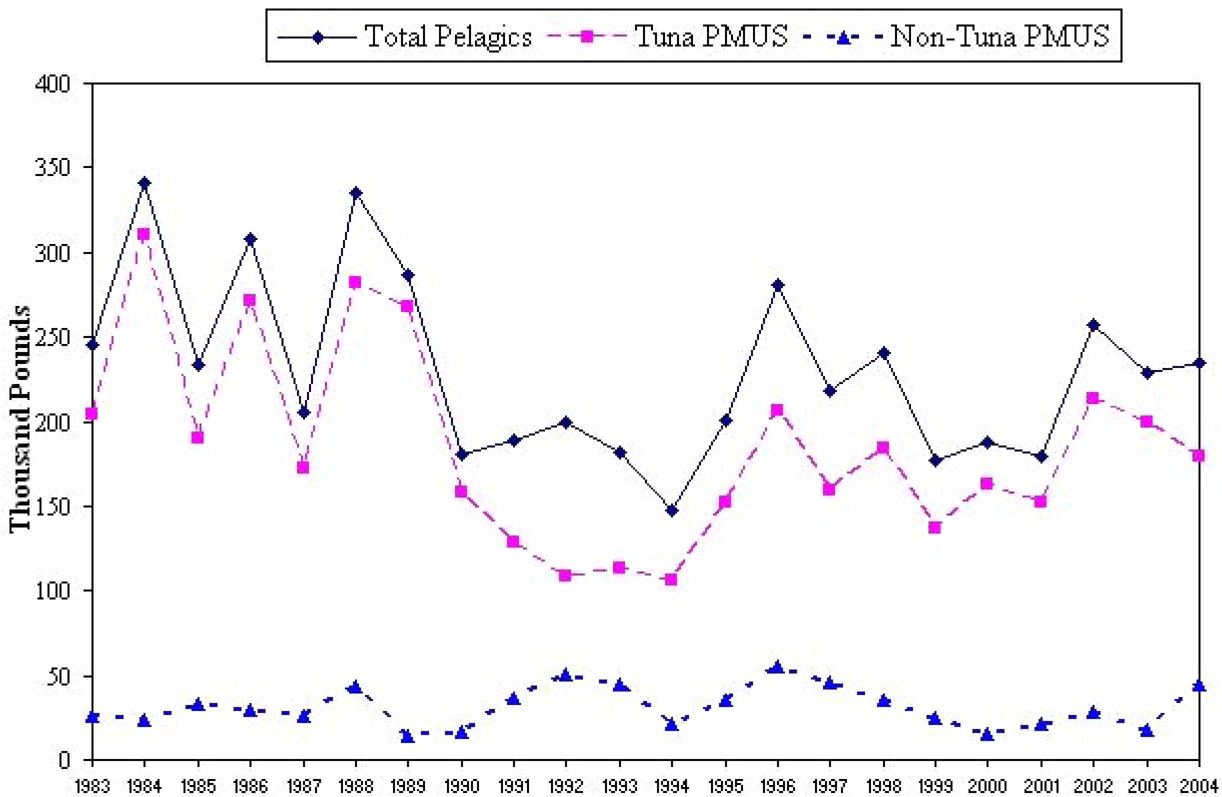
During the 1970s, surveys for precious coral in the waters surrounding CNMI were performed (Grigg and Eldridge 1975). The study focused on the presence of pink and red corals (*Corallium spp*.) and black coral (*Antipathes spp*.). Very little precious coral resources were found in these surveys.

3.5.2.3.2 Pelagic Fisheries

The CNMI's pelagic fisheries occur primarily from the island of Farallon de Medinilla south to the island of Rota. Trolling is the primary fishing method utilized in the pelagic fishery. The pelagic fishing fleet consists primarily of vessels less than 24 ft in length which usually have a limited 20-mile travel radius from Saipan.

The primary target and most marketable species for the pelagic fleet is skipjack tuna (67% of 2004 commercial landings). Yellowfin tuna and mahimahi are also easily marketable species but are seasonal. During their runs, these fish are usually found close to shore and provide easy targets for the local fishermen. In addition to the economic advantages of being near shore and their relative ease of capture, these species are widely accepted by all ethnic groups which has kept market demand fairly high. Figure 13 presents historical data on pelagic landings in CNMI. It is estimated that in 2004, 68 fishery participants made 235,382 lbs of commercial landings of pelagic species with a total ex-vessel value of $466,490 (WPRFMC 2005b).

Figure 13: Pelagic Landings in CNMI 1983-2004
(Source: CNMI DLNR-DFW)



3.5.2.4 Communities

Fishery resources have played a central role in shaping the social, cultural and economic fabric of the CNMI. The aboriginal peoples indigenous to these islands relied on seafood as their principal source of protein and developed exceptional fishing skills. Later immigrants to the islands from East and Southeast Asia also possessed a strong fishing tradition. Under the MSA, the CNMI is defined as a fishing community.

The CNMI consists of 14 islands, five of which are inhabited, with a total land area of 176.5 square miles spread over about 264,000 square miles of ocean. The Northern Mariana Islands became part of the Pacific Trust Territory administered by the United States under a mandate granted in 1947. The Covenant that created the Commonwealth and attached it to the United States was fully implemented in 1986, pursuant to a Presidential Proclamation that terminated the Trust Territory of the Pacific Islands as it applied to the Northern Mariana Islands.

Per capita income in the CNMI in 1999 was $9,151. The median household income for the CNMI as whole was $22,898. For Saipan, the median household income was $19,698 in the first quarter of 1999, as compared to $21,457 in 1990. The Commonwealth had an unemployment rate in 1999 of 5.5 percent. Forty-six percent of the CNMI population was at or below poverty in 1999 (Census 2000).

In 2000, CNMI had 20,378 men ages 16 and over in the labor force, of whom 96 percent or 19,458 were employed. There were 24,093 women ages 16 and over in the labor force, of which 97 percent were employed (Census 2000). The economy of the CNMI has historically benefited substantially from financial assistance from the United States, but in recent years this assistance has declined as locally generated government revenues have grown. Between 1988 and 1996, tourism was the commonwealth's largest income source. During that period tourist traffic to the CNMI tripled from 245,505 to 736,117 (BOH 1999c). Total tourist expenditures in the CNMI were estimated to be a record $587 million in 1996. In 1997 and 1998, however, the loss of air service between the CNMI and Korea, together with the impact of the Asian financial crisis on both Korean and Japanese travelers, caused tourist arrivals in the CNMI to drop by one-third (BOH 1999c).

More recently garment production has been an important industry, with shipments of $1 billion to the United States under duty and quota exemptions during 1999 (BOH 1999c). The garment industry is credited with preventing an economic depression in the Commonwealth following the decline of its tourist industry, but the future of the CNMI's garment manufacturers is uncertain. When the Commonwealth was created it was granted an exemption from certain U.S. immigration, naturalization and labor laws. These economic advantages are now a matter of national political debate centered on what some regard as unfair labor practices in the CNMI's garment industry. The two main advantages for manufacturing garments in the CNMI are low-cost foreign labor and duty-free sale in the United States. The controversy over labor practices in the CNMI may cause the Commonwealth to lose these unique advantages, forcing garment-makers to seek alternative low-cost production sites. The end of the quota on foreign textiles in 2005 may cause garment manufacturers to move to China, which has some competitive advantages (BOH 2004).

In the early 1980s, U.S. purse seine vessels established a transshipment operation at Tinian Harbor. The CNMI is exempt from the Jones Act, which requires the use of U.S.-flag and U.S.-built vessels to carry cargo between U.S. ports. The U.S. purse seiners took advantage of this exemption by offloading their catch at Tinian onto foreign vessels for shipment to tuna canneries in American Samoa. In 1991, a second type of tuna transshipment operation was established on Saipan (Hamnett and Pintz 1996). This operation transships fresh tuna caught in the Federated States of Micronesia from air freighters to wide-body jets bound for Japan. The volume of fish flown into and out of Saipan is substantial, but the contribution of this operation to the local economy is minimal (Hamnett and Pintz 1996).

With the exception of the purse seine support base on Tinian (now defunct), the CNMI has never had a large infrastructure dedicated to commercial fishing. The majority of boats in the local fishing fleet are small, outboard engine-powered vessels. Between 1994-1998, the annual ex-vessel value of commercial landings of bottomfish and pelagic species has averaged about $473,900, which bottomfish accounts for about 28% of the total revenues (WPFMC 1999). Existing planning data for the CNMI are not suited to examining the direct and indirect contributions attributed to various inter-industry linkages in the economy. It is apparent, however, that fishing by the local small-boat fleet represents only a small fraction of the economic activity in the commonwealth.

3.5.3 Guam

At 560 km², Guam is the largest and most populated (~ 160,000) island in Micronesia. Guam has a tropical climate with average air temperatures around 80° F and relative humidity around 90 percent near the coast. Prevailing winds are northeasterly trade winds which average around 10 knots. Guam's annual average rainfall amount is around 90 inches, with over 75 percent of the rain occurring in wet season between July and November (Eldredge 1983). Due to its position in the western Pacific Ocean, Guam experiences a high number of tropical cyclones during its wet season. For example, between 1948 and 1975, more than 70 cyclones came within 200 miles of Guam. Of those 70, 26 were categorized as typhoon strength (> 64 knot winds) (Eldredge 1983). Over the last 10 years, Guam has been directly hit by four typhoons with sustained winds of over 150 mph (Porter et al. 2005).

3.5.3.1 Marine Environment

***Coral Reefs*:** Approximately 50% of Guam's 153 km shoreline is surrounded by well developed coral reefs (Randall & Myers 1983, Myers 1997). Most of the reefs are fringing reefs (up to 600m wide), except for the broad barrier reef enclosing the shallow Cocos Lagoon at the southwest tip of the island (Eldredge 1983, Randall & Myers 1983). A raised barrier reef (Cabras Island), a greatly disturbed barrier reef (Luminao Reef) and a coral bank (Calalan Bank), enclose the deep lagoon of Apra Harbor (Randall & Myers 1983). Patch reefs are also associated with Anae Island on the southwest coast and at Pugua Patch Reef (or Double Reef) on the northwest coast (Randall & Myers 1983). All of the reef flats, lagoons, patch reefs and outer reef slopes surrounding Guam are located within territorial waters (Hunter 1995, Myers 1997).

The potential coral reef area around Guam is estimated at 108 km² (within 10 fm curve) and 276 km² (within 100 fm curve), respectively (Rohman et al. in press). Most of the reefs located in territorial waters (0-3 nm), while reefs located at the offshore banks are in Federal waters.

The health of Guam's coral reefs varies considerably with impacts ranging from anthropogenic and natural sources. Coral bleaching events have not been major threat to Guam's coral reefs as only two have been observed since 1970 (Porter et al. 2005).

Typhoons are frequent on Guam (up to five major typhoons per year: Eldredge 1983, USDA 1995, Birkeland 1997b), which cause some damage to the reefs (Randall & Eldredge 1977, Birkeland 1997b). However, the reefs on Guam tend to experience less physical damage from these storms than is the case in other areas, because corals in exposed locations are "adapted" to these rough conditions and grow in low profile growth forms (Randall & Eldredge 1977, Birkeland 1997b). As such, severe typhoon damage to the reefs on Guam tends to be localized in areas that are usually protected from heavy wave action by the shape of the coastline (Birkeland 1997b).

Several outbreaks of the crown-of-thorns starfish have also occurred on Guam over the last few decades (Birkeland 1997b). One outbreak in the 1960s, caused severe catastrophic mortality (90%) of reef slope corals along 38 km of Guam's northwest coast (Randall 1971, 1973, Colgan 1981, 1982, Chesher 1986). However by 1981, the reefs had started to recover from the starfish invasion and coral cover was high again (65%: Colgan 1987). Occasional earthquakes and El Nino events have also been known to cause substantial damage to the reefs on Guam (Birkeland 1997b). However, the biggest threat to Guam's reefs appears to be from anthropogenic effects, including overfishing and habitat degradation due to poor land use practices, urbanization and development (Myers 1997). Sedimentation and overfishing are probably the most serious problems causing coral reef degradation on Guam (Myers 1997, Birkeland 1997b). For example, Birkeland (1997b) reported that the rates of coral replenishment have been substantially reduced on Guam over the last 20 years, possibly as a result of increased sedimentation and the overfishing of herbivores (Birkeland 1997b). As a result of the loss of living cover and the lack of replenishment of these reefs, coral cover on the island has declined substantially over time (Birkeland 1997b). This effect has been most pronounced on the reef slopes, and coral cover is still reasonably high in some places on the reef flat (Birkeland 1997b). Other anthropogenic impacts that may have affected coral reef health on Guam include industrial pollution, non-point source pollution, oil spills, sewage and coastal construction (Myers 1997).

Current opinion is that coral reef health varies around the island of Guam. In general many of the reefs on the southern part of the island tend to be in poor condition, because of the high population base, extensive coastal development, good reef access, and high runoff of sediments onto the reefs from large rivers (Myers 1997, Porter et al. 2005). One example is the reef between Facpi Point and Umatac on the southwest side of the island, which has been buried by sediment in recent years (R. Myers, R. Richmond and S. Amesbury pers. comm.). By contrast, the reefs on the northern part of the island (e.g. Ritidian Point and Pati Point) tend to be in better condition because there are fewer people, less development, less access to the reef, and no major rivers (R. Myers, C. Birkeland, S. Amesbury and R. Sakomoto pers. comm.)

Virtually nothing is known of the coral reef resources on the banks in Federal waters in Guam (Myers 1997), since they are in remote locations and difficult to access (DAWR personnel pers. comm.). The small amount of information that is available is based on anecdotal observations by scientists and fishermen, who have made one or more dives on the banks (e.g. C. Birkeland and E. Poppe Jr. pers. comm.). In general, the coral reefs at Rota, Santa Rosa and White Tuna Banks are thought to be in good condition, while fishery resources at Galvez Bank are believed to in lower abundance because it is closer to Guam and more heavily fished (J. Cruz pers. comm.).

Deep Reef Slope, Banks, and Seamount Habitat: Deepwater banks are located at several locations around the island, four of which are located in Federal waters (Rota Bank to the north and Galvez, Santa Rosa and White Tuna Bank to the south (Donaldson 1995, Hunter 1995, Myers 1997).

Pelagic Habitat: Generally, the major surface current affecting Guam is the North Equatorial Current (see Figure 4), which flows westward through the islands. Sea surface temperatures off Guam vary between 80.9° – 84.9° F, depending on the season. The mixed layer extends to depths between 300-400 ft (Eldredge 1983).

3.5.3.2 Protected Species

Sea Turtles

Both hawksbill and green sea turtles are known to nest on Guam, and there have been occasional sightings of leatherback turtles as well. Nesting surveys for green sea turtles have been done on Guam since 1973 with the most consistent data collected since 1990. There have been up to 60 nesting females observed annually, with a generally increasing trend over the past 12 years Aerial surveys done in 1999-2000 also found an increase in green sea turtle sightings around Guam. (Cummings 2002).

Marine Mammals

Cetaceans: Humpback whales (*Megaptera novaeangliae*), Risso's dolphins (*Grampus griseus*), Cuvier's beaked whales (*Xiphias cavirostris*), pygmy sperm whales (*Kogia breviceps*), pilot whales (*Globicephala melaena*), striped dolphins (*Stenella coeruleoalba*), and the pantropic whitebelly spinner dolphin (*Stenella longirostris longirostris*) have been sighted around Guam.

Pinnipeds and Sirenians: No pinnipeds or sirenians species are known to occur in Guam waters.

Seabirds

The following seabirds are believed to be residents of Guam; wedge-tailed shearwater (*Puffinus pacificus*), white-tailed tropicbird (*Phaethon lepturus*), red-tailed tropicbird (*Phaethon lepturus*), masked booby (*sula dactylatra*) and brown booby (*Sula leucogaster*). Other species believed to be visitors to Guam include; streaked shearwater (*Calonectris leucomelas*), short-tailed shearwater (*Puffinus tenuirostris*), Christmas shearwater (*Puffinus nativitatis*), Newell's shearwater (*Puffinus auricularis*), Audobon's shearwater (*Puffinus iherminieri*), Leach's storm-petral (*Oceanodroma leucorhoa*), Matsudaira's storm-petral (*Oceanodroma matsudairae*), and the red-footed booby (*Sula sula*).

3.5.3.3 Fisheries

Under the authority of the MSA, the Council established (approved by Secretary of Commerce) thresholds to determine for overfishing (fishing mortality) and overfished (stock biomass) conditions for fisheries of the Western Pacific Region. Currently, no fishery in Guam has been determined by NMFS to be experiencing overfishing or to be overfished.

3.5.3.3.1 Demersal Fisheries

Coral Reef: Guam's coral reef fisheries are culturally and economically important. The gear most often used to harvest coral reef resources include hook and line, cast nets, spears, and surround nets. The most common fish harvested include species of the following: kyphosidae (rudderfish), acanthruidae (surgeonfish), lethrinidae (emperors), scaridae (parrotfish), and labridae (wrasses). Invertebrate harvests include octopus, spiny lobster, trochus shells, conch shells, and reef crabs. Total coral reef fish landings for 2002 and 2003 were estimated at 273,799 lbs and 306,626 lbs, respectively (Porter et al. 2005).

Crustacean: Fishing for crustaceans around Guam occurs in inshore territorial waters, usually in a subsistence or recreational context. In 2004, however, two Crustacean FMP permits were registered to vessels to fish in the EEZ around Guam. The activities of these vessels (if any) including catch levels, composition, or location are unknown at this time. (A. Katekaru, NMFS-PIRO, pers. comm., Aug. 2004). It is estimated that a total of 2,225 lbs of spiny lobsters with a total ex-vessel value of $7,279 were commercially harvested from waters around Guam in 2003 (NOAA 2004).

Precious corals: There is no precious coral fishery currently operating around Guam, nor have there been any reported or observed landings of precious corals harvests from the EEZ around Guam.

Bottomfish: There are two distinct bottomfish fisheries on Guam that can be separated by depth and species composition. The shallow water complex (<500 feet) makes up a larger portion of the total bottomfish effort and usually the harvest, comprised primarily of reef-dwelling snappers, groupers, and jacks of the genera *Lutjanus*, *Lethrinus*, *Aprion*, *Epinephelus*, *Variola*, *Cephalopholis* and *Caranx*. The deepwater complex (>500 feet) consists primarily of groupers and snappers of the genera *Pristipomoides*, *Etelis*, *Aphareus*, *Epinephelus*, and *Cephalopholis*.

Bottomfishing on Guam is a combination of recreational, subsistence, and small-scale commercial fishing. The majority of the participants in the bottomfish fishery operate vessels less than 25 feet long and primarily target the shallow-water bottomfish complex (WPRFMC 2003a). The shallow-water component is the larger of the two in terms of participation because of the lower expenditure and relative ease of fishing close to shore (Myers 1997). Participants in the shallow-water component seldom sell their catch because they fish mainly for recreational or subsistence purposes (WPRFMC 2003a). The commercially-oriented highliner vessels tend to be longer than 25 feet, and their effort is usually concentrated on the deep-water bottomfish complex. Most fishermen troll for pelagic fish to supplement their bottomfishing effort and most of those who sell their catch also hold jobs outside the fishery (WPRFMC 2003a).

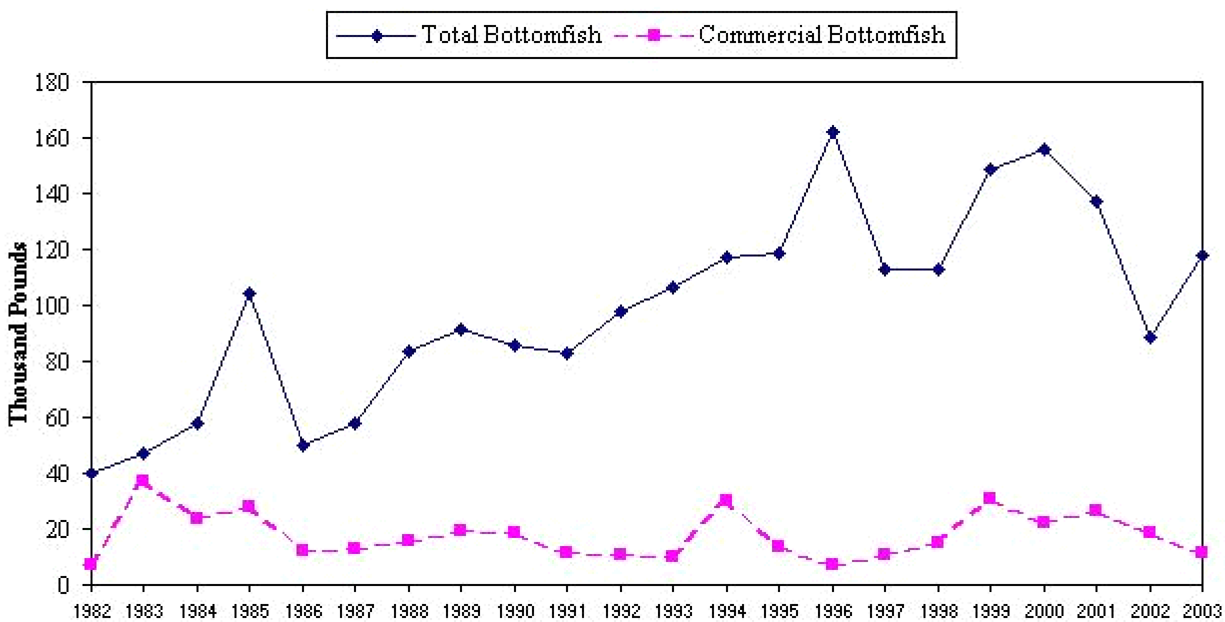
Smaller vessels (< 25 ft) mostly target the shallow-water bottomfish complex and fish for a mix of recreational, subsistence, and small-scale commercial purposes. Some vessels fishing the offshore banks – particularly the few relatively large vessels (> 25 ft) that fish primarily for commercial purposes – target the deep-water bottomfish complex. At least one such vessel has been engaged in a venture that exports deep-slope species – particularly *onaga* – to Japan. It is possible that some vessels fishing on the banks around Guam land their catches in the CNMI (WPRFMC 2002a). In 1997, a highliner vessel made several bottomfishing trips to a seamount located 117 miles west of Guam (WPRFMC 2003c).

The Agana Boat Basin is centrally located on the western leeward coast and serves as the island's primary launch site for boats fishing areas off the central and northern leeward coasts and the northern banks. The Merizo boat ramp, Seaplane Ramp in Apra Harbor, Umatac boat ramp, and Agat Marina are boat launch sites which provide access to the southern coast, Apra

Harbor, Cocos Lagoon, and the southern banks. The Agat Marina in particular, located between the Agana Boat Basin and the Merizo boat ramp, provides trailered boats from the northern and central areas of the island a closer and more convenient launch site to the southern fishing grounds. At Ylig Bay, a paved parking area and maintenance of the brush along the highway has helped increased the number of boats accessing the east side of the island.

Guam's bottomfish fishery can be highly seasonal, with effort significantly increasing when sea conditions are calm, generally during the summer months. During these periods, bottomfishing activity increases substantially on the offshore banks (in Federal waters), as well as on the east side of the island (in territorial waters), a more productive fishing area that is inaccessible to small boats during most of the year due to rough seas. Historical data on Guam bottomfish landings is provided in Figure 14.

Figure 14: Guam Bottomfish Landings
(source: WPFMC 2003)



According to Myers (1997), less than 20% of the total shallow-water marine resources harvested in Guam are taken outside 3 miles, primarily because the offshore banks are less accessible. Most offshore banks are deep, remote, and subject to strong currents. Anecdotal evidence from local fishermen suggest that much of their catch on these banks are taken by sharks before the fish are brought on board. Generally, Guam's offshore banks are only accessible during calm weather in the summer months (May to August/September). Eleven Mile Bank is the closest, however, Galvez Bank is also accessible and, consequently, fished most often. In contrast, the other banks (White Tuna, Santa Rose, and Rota) are remote and can only be fished during exceptionally good weather conditions (Green 1997). Local fishermen report that up to ten commercial boats, with two to three people per boat, and some recreational boats, use the banks when the weather is good (Green 1997). The banks are fished using two methods: bottomfishing by hook-and-line and jigging at night for bigeye scad (*Selar crumenophthalmus*)

(Myers 1997). Catch composition of the shallow-bottomfish complex (or coral reef species) is dominated by lethrinids. Other important components of the bottomfish catch include lutjanids, carangids, serranids, and sharks. Holocentrids, mullids, labrids, scombrids, and balistids are minor components. It should be noted that at least two of these species (*Aprion virescens* and *Caranx lugubris*) also range into deeper water and some of the catch of these species occurs in the deepwater fishery. It is estimated that in 2004, 347 domestic vessels landed 109,301 pounds of bottomfish in Guam. Of this, 25,054 lbs were sold for a total ex-vessel value of $73,466 (WPRFMC 2005)

Participants in small-scale offshore fisheries live throughout the island of Guam and are not concentrated in specific locales. Surveys of fishery participants found that these individuals reside throughout the island (Rubinstein 2001). With the small size of Guam, the dispersal of fishery participants and extensive community networks for sharing locally caught fish, it is likely that the social benefits of fishing are widely shared by most of the island's long-term residents (WPRFMC 2003a).

Charter fishing has been a substantial component of the fishery since 1995, accounting for about 15-20% of all bottomfishing trips from 1995 through 2004 (WPRFMC 2005). Charter vessels typically make multiple two-to-four hour trips on a daily basis. The charter fleet includes both vessels that engage in both trolling and bottomfishing trips, and larger bottomfishing-only vessels that can accommodate as many as 35 patrons per trip. These larger vessels consistently fish in the same general area and release most of their catch, primarily small triggerfish, small groupers, and small goatfish. They occasionally keep larger fish and use a portion of the catch to serve as sashimi for their guests.

3.5.3.3.2 Pelagic Fisheries

Guam's pelagic fisheries consist of primarily small, recreational, trolling boats that are either towed to boat launch sites or berthed in marinas and fish only within local waters, either within the EEZ around Guam or on some occasions in the adjacent EEZ waters around the Northern Mariana Islands.

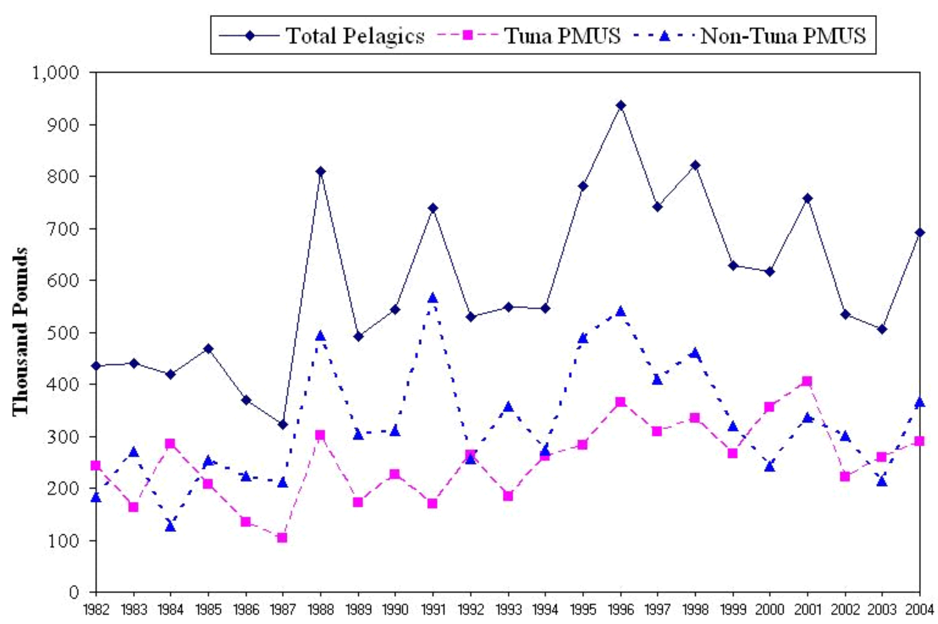
Domestic annual pelagic landings in Guam have varied widely, ranging between 322,000 and 937,000 lbs in the 23-year time series. The 2004 total pelagic landings were approximately 691,366 lbs, an increase of 36% compared with 2003. Of this total, it is estimated that 285,545 lbs were sold for a total ex-vessel revenue of $433,911 (WPRFMC 2005).

Landings consisted primarily of five major species: mahimahi (*Coryphaena hippurus*), wahoo (*Acanthocybium solandri*), bonita or skipjack tuna (*Katsuwonus pelamis*), yellowfin tuna (*Thunnus albacares*), and Pacific blue marlin (*Makaira mazara*). Other minor pelagic species caught include rainbow runner (*Elagatis bipinnulatus*), great barracuda (*Sphyraena barracuda*), kawakawa (*Euthynnus affinis*), dogtooth tuna (*Gymnosarda unicolor*), double-lined mackerel *(Grammatorcynus bilineatus*), oilfish (*Ruvettus pretiosus*), and three less common species of barracuda. Sailfish and sharks were also known to be caught during 2004 but these species were not encountered during offshore creel surveys.

There are wide year-to-year fluctuations in the estimated landings of the five major species. 2004 mahimahi catch increased more than 134% from 2003, and reached the highest level since 1998. Wahoo catch totals increased 83% from 2003, and were the sixth highest total during the 23 year recording period. Pacific blue marlin landings decreased 28% from 2003, and were 24% below the 23 year average. Supertyphoon Pongsona's direct hit on Guam in December 2002 and subsequent negative impact on fishing during the first quarter of 2003 probably account for the low numbers of mahimahi caught during 2003. Participation and effort generally increased in 2004 with the number of trolling boats up by eight percent (WPRFMC 2005)

The number of boats involved in Guam's pelagic or open ocean fishery gradually increased from 193 in 1983 to 469 in 1998. This number decreased until 2001, but then began increasing, and has been increasing since. There were 401 boats active in Guam's domestic pelagic fishery in 2004. A majority of the fishing boats are less than 10 meters (33 feet) in length and are usually owner-operated by fishermen who earn a living outside of fishing. Most fishermen sell a portion of their catch at one time or another and it is difficult to make a distinction between recreational, subsistence, and commercial fishers. A small, but significant, segment of Guam's pelagic fishery is made up of marina-berthed charter boats that are operated primarily by full-time captains and crews. These operations were responsible for 22 percent of all domestic pelagic fishing trips from Guam in 2004 (WPRFMC 2005). Figure 15 provides the estimated annual total domestic pelagics catch in Guam.

Figure 15: Estimated Annual Total Domestic Pelagics Catch in Guam 1982-2004
(source: WPFMC 04)



3.5.3.4 Communities

Under the MSA, Guam is designated as fishing community. However, Guam's history, culture, geography and relationship with the U.S. are vastly different from those of the typical fishing community in the continental U.S.

Over the centuries of acculturation beginning with the Spanish conquest in the late 17th century, many elements of traditional Chamorro culture in Guam were lost. But certain traditional values, attitudes and customs were retained to become a part of contemporary life. Amesbury and Hunter-Anderson et al. (1989:48) note that the practice of sharing one's fish catch with relatives and friends during Christian holidays is rooted in traditional Chamorro culture:

> *A strongly enduring cultural dimension related to offshore fishing is the high value placed on sharing of the catch, and the importance of gifts of fish to relatives and friends.*

Based on creel surveys of fishermen, only about one-quarter to one-third of the inshore catch is sold. The remainder enters non-commercial channels (Knudson 1987). Reef and bottomfish continue to be important for social obligations, such as fiestas and food exchange with friends and families. One study found a preference for inshore fish species in non-commercial exchanges of food (Amesbury and Hunter-Anderson 1989).

The social obligation to share one's fish catch extends to part-time and full-time commercial fishermen. Such gifts are often reef fish or shallow-water bottomfish (Amesbury and Hunter-Anderson 1989). Even when fish are purchased informally by friends, neighbors or relatives of the fisherman, the very personal marketing tends to restrain the price asked (WPRFMC 2003a). Domestic fishing on Guam supplements family subsistence, which is gained by a combination of small scale gardening, ranching and wage work (Amesbury and Hunter-Anderson 1989). The availability of economic activities such as part-time fishing is among the major reasons that Guam has not experienced more social problems during times of economic hardship and increasing unemployment. The subsistence component of the local economy has gained significance in recent years with the downturn in Guam's major industries and increasing unemployment.

Fishing in Guam continues to be important not only in terms of contributing to the subsistence needs of the Chamorro people but also in terms of preserving their history and identity. Fishing assists in perpetuating traditional knowledge of marine resources and maritime heritage of the Chamorro culture.

The island of Guam was ceded to the United States following the Spanish American War of 1898 and has been an unincorporated territory since 1949. The main income sources on Guam include tourism, national defense, and trade and services. Per capita income in Guam was $12,722 in 1999, up from $10,152 in 1991. Median household income was $39,317 in 1999, up from $31,118 in 1991. Twenty-three percent of the population in 1999 was at or below poverty level (Guam Census 2000).

The Guam Department of Labor estimated the number of employees on payroll to be 64,230 in 1998, a decrease of 3.8 percent from the 1997 figure. Of the 64,230 employees, 44,780 were in the private sector and 19,450 were in the public sector. The Federal government employs 7.6 percent of the total work force, while the Government of Guam employs 22.7 percent. Guam had an unemployment rate of 15.2 percent in 1999. As of 2000, Guam had 39,143 men age 16 and over in the labor force, of whom 81% were employed. There were 29,751 women age 16 and over in the labor force, of which 86% were employed (Guam Census 2000).

The major economic factor in Guam for most of the latter part of the twentieth century was the large-scale presence of the U.S. military (BOH 1999b). In the 1990s, however, the military's contribution to Guam's economy has waned and been largely replaced by Asian tourism. Guam's macro-economic situation exhibited considerable growth between 1988 and 1993 as a result of rapid expansion of the tourist industry. In fact, Guam's economy has become so dependent on tourists from Asia, particularly Japan, that any significant economic, financial and foreign exchange development in the region has had an immediate impact on the territory (BOH, 1999b). During the mid- to late-1990s, as Japan experienced a period of economic stagnation and cautious consumer spending, the impact was felt just as much in Guam as in Japan. Visitor arrivals in Guam dropped 17.7 percent in 1998. Despite recent efforts to expand the tourist market, Guam's economy remains dependent on Japanese tourists.

The Government of Guam has been a major employer on Guam for many years. However, recent deficits have resulted from a steady rise in government spending at the same time that tax bases have not kept up with spending demands. Many senior government workers have been offered and have accepted early retirement to reduce the payroll burden.

In the 1990s, after three decades of troop reductions, the military presence on the island diminished to the lowest level in decades, but with the post-9/11 emphasis on homeland security, the war in Iraq, and repositioning of military assets from Asia and the mainland U.S., military spending on Guam has rebounded significantly, and the effects have been felt throughout the economy including in employment and housing prices (Los Angeles Times, July 25, 2004).

The importance of commercial fishing in Guam lies mainly in the territory's status as a major regional fish transshipment center and re-supply base for domestic and foreign tuna fishing fleets. Among Guam's advantages as a home port are well-developed and highly efficient port facilities in Apra Harbor; an availability of relatively low-cost vessel fuel; a well-established marine supply/repair industry; and recreational amenities for crew shore leave (Hamnett and Pintz 1996). In addition, the territory is exempt from the Nicholson Act, which prohibits foreign ships from landing their catches in U.S. ports. Initially, the majority of vessels calling in Apra Harbor to discharge frozen tuna for transshipment were Japanese purse seine boats and carrier vessels. Later, a fleet of U.S. purse seine vessels relocated to Guam, and since the late 1980s, Guam has become an important port for Japanese and Taiwanese longline fleets. The presence of the longline and purse seine vessels has created a demand for a range of provisioning, vessel maintenance and gear repair services.

By the early 1990s, an air transshipment operation was also established on Guam. Fresh tuna is flown into Guam from the Federated States of Micronesia and elsewhere on air cargo planes and out of Guam to the Japanese market on wide-body passenger planes (Hamnett and Pintz, 1996). A second air transshipment operation that began in the mid-1990s is transporting to Europe fish that do not meet Japanese sashimi market standards.

Guam is an important re-supply and transshipment center for the international tuna longline fleet in the Pacific. However, the future of home port and transshipment operations in Guam depends on the island's ability to compete with neighboring countries that are seeking to attract the highly mobile longline fleet to their own ports. Trends in the number of port calls made in Guam by various fishing fleets reflect the volatility of the industry. The number of vessels operating out of Guam decreased by almost half from 1996 to 1997, and further declined in 1998 (Hamnett and Anderson 2000).

The Guam Department of Commerce reported that fleet expenditures in Guam in 1998 were about $68 million, and a 1994 study estimated that the home port and transshipment industry employed about 130 people (Hamnett and Pintz 1996). This industry constitutes an insignificant percentage of the gross island product, which was about $2.99 billion in 1996, and is of minor economic importance in comparison to the tourist or defense industries (Hamnett and Anderson 2000). Nevertheless, home port and transshipment operations make an important contribution to the diversification of Guam's economy (Hamnett and Pintz 1996). As a result of fluctuations in the tourism industry and cuts in military expenditures in Guam, the importance of economic diversification has increased.

3.5.4 Hawaii

In the central North Pacific Ocean, roughly 2,500 miles southwest of North America, lies the Hawaiian Archipelago. This 137-island chain stretches nearly 1,500 miles from Kure Atoll in the Northwestern Hawaiian Islands (NWHI) to the island of Hawaii at the southern tip of the inhabited Main Hawaiian Islands (MHI). The total land area of the Hawaiian islands is 6,423 sq miles. The NWHI comprise roughly 1,000 miles of the 1,500 mile archipelago, and are composed of volcanic islands, atolls, shoals, and submerged banks.

The NWHI are unique as they comprise the northernmost coral reef ecosystem (Kure Atoll) on the planet. The water temperatures experienced there are assumed to be the lower limit for corals to thrive and reefs to grow (~ 65° F). Grigg (1982) suggests that Kure Atoll lies at the "Darwin Point" for reef development, a geographical limit beyond which corals and coralline algae can no longer deposit enough calcium carbonate to keep up with the subsidence of the area's volcanic base. It is theorized that reefs at latitudes higher than the Darwin Point fail to remain at sea level and sink below the photic zone within which growth can occur (Grigg 1982).

The Hawaii Archipelago is subject to high wave energy produced from weather systems generated off the Aleutian Islands and other areas of the North Pacific. Such waves can have major effects on the nearshore environment. For example, high wave energies can break off pieces of coral, move underwater boulders, shift large volumes of sand, and erode islands (Grigg 1997).

Due its position in the North Pacific, Hawaii (more specifically the NWHI) also acts as a sink for a multitude of marine debris originating from Pacific-rim countries. Perhaps the most damaging is derelict fishing gear such as nets and rope that are believed to be carried by ocean currents from North Pacific trawl fisheries. Other types of debris include materials made from rubber and plastics (e.g. lighters). Marine debris impacts the nearshore environment of the NWHI by choking and breaking coral reefs, entangling marine life, and carrying invasive species. Since 1996, NMFS has led a multi-agency cleanup effort that has removed nearly 450 mt of derelict fishing nets and other debris from the NWHI (J. Asher 2005, pers. comm.) In recent years, the effort has removed over 100 tons of marine debris per year. The total amount of marine debris accumulating each year in NWHI is unquantified but known to be substantial.

3.5.4.1 Marine Environment

__Coral Reefs__

The total potential coral reef area in Hawaii (MHI and NWHI) is estimated to be 2,826 km² within the 10 fm curve, and 20,437 km² within the 100 fm curve, respectively (Rohnman et al. 2005). The MHI represent the younger portion of the Hawaii Archipelago, and have less well-developed fringing reefs that have not subsided as far below sea level as those in the NWHI (Smith 1993). The potential coral reef area surrounding the MHI is estimated at 1,231 km² within the 10 fathom contour (Rohnman et al. in press).

Grigg (1997) summarized the condition of the reefs on each island and concluded that 90% of Hawaii's reefs are healthy (Grigg 1997). However, there are increasing problems with excessive levels of fishing, and environmental degradation associated with a growing human population, urbanization and development (Friedlander 1996, Grigg 1997, J. Maragos pers. comm.). Focal points for coral reef degradation in Hawaii include reefs adjacent to urban areas, coastal recreational developments (e.g. hotels, golf courses), and ocean outfalls (Jokiel & Cox 1996 in Friedlander 1996, J. Maragos pers. comm.).

A combination of natural and anthropogenic factors, including wave energy, depth, sedimentation, turbidity, light, nutrient concentration and other biological factors, control coral reef community structure in Hawaii (Grigg 1997). Most coastline areas in the State are exposed to the open ocean, and the reefs in these areas are frequently disturbed by wave induced mortality (Grigg 1997). As such, the only significant build-up of reefs in the MHI is found in areas that are reasonably sheltered from open ocean swells and at depths that are not constrained by sea level (Grigg 1997). Such areas are typically restricted to embayments and areas sheltered from wave exposure by nearby islands (Grigg 1997). Examples include the Kona Coast of Hawaii; the south coast of west Maui; north coast of Lanai and Kauai; Kaneohe Bay; Hanauma Bay; and Barber's Point on Oahu (Des Rochers 1992, J. Maragos pers. comm.). In most places, the modern Holocene reefs consist of only a thin veneer on top of the older, Pleistocene reefs, which suggests that no accretion of living corals is taking place (Grigg 1997). Slow coral growth, low rates of recruitment and sedimentation have also been proposed as factors that have contributed to the slow rate of coral reef formation in Hawaii (Friedlander 1996).

In general, impacts related to anthropogenic factors such as point and non-point pollution, tend to be of most significant in wave sheltered environments or in areas with high residence time such as embayments and lagoons (Grigg 1997, Freidlander et al. 2005). In cases where the ecology of reefs is under primary or dominant control by wave's forces, the potential effects of pollution may be of less pronounced, except with respect to aesthetic values or water quality and human health (Grigg 1997). Friedlander (1996) and Grigg (1997) both noted that excessive fishing is a serious problem throughout the MHI. Grigg (1997) also found that each of the MHI is characterized by other specific and localized threats to coral reef health.

Oahu: Oahu, being the population center of Hawaii, ranks highest among the MHI in terms of coral reef resource problems and the need for better long-term management (Grigg 1997a). Most of the open coastline of Oahu is fringed by coral reefs with low natural coral cover due to wave action (Grigg 1997). The best reef development is found in embayments or shelter areas, such as Kaneohe Bay or Hanauma Bay (Grigg 1997). Reef communities are generally healthy except for local areas where shoreline use is high or in some embayments where water circulation is restricted (Grigg 1997). Point and non-point source pollution has degraded many of these environments and over exploitation of coral reef fishes has reduced fish abundance. (Grigg 1997). Notwithstanding these problems, Grigg (1997a) reports that many improvements in coastal environments have occurred on Oahu in recent years. All shallow nearshore sewage discharges have been replaced by deepwater outfalls, and better land management practices and the curtailment of dredging and filling activities have greatly reduced sedimentation problems to coral reef island wide (Grigg 1997).

Maui: Most coral reefs on Maui are also under primary control of wave forces (Grigg 1997). Healthy reefs can be found off Honokowai on the western end and the stretch of coastline between Olowalu and Papawai off the south coast of West Maui (Grigg 1997). Both of these areas were sheltered from the effects of Hurricane Iniki in 1992, and coral cover ranges from 50-80% (depth: 10-20m, Grigg 1997). Other pristine reefs also exist at 30-40 m in Au'au Channel where they are totally sheltered from wave stress (Grigg 1997). Exposed areas, some with reefs containing >50% coral cover, were devastated by Hurricane Iniki, which resulted in mortality of up to 100% (E. Brown pers. comm. in Grigg 1997).

The two most significant environmental problems affecting coral reefs on Maui are excessive fishing and increases in various species of invasive algae which may be related to nutrient loading (Grigg 1997), periodic natural upwelling, the low abundance of urchins or high fishing pressure on herbivorous fishes (Grigg 1997).

Lanai: Virtually all of the reefs on Lanai are in a healthy condition, although those on the northern half experience episodic mortally as the result of sediment run-off (Grigg 1997, J. Maragos pers. comm.in Green 1997). None of Lanai's reefs seem to experience pollution, and most experience fishing pressure (Grigg 1997).

Molokai: The south coast of Molokai supports the longest fringing reef in Hawaii (~35 miles long: J. Maragos pers. comm. in Green 1997). The condition of this reef varies from poor to excellent, with much of the reef degradation associated with sedimentation due to poor land use practices (J. Maragos pers. comm). The reefs of Molokai have been subjected to widespread and high fishing levels as well as sedimentation (Grigg 1997), although other anthropogenic effects on these reefs appear minimal (Grigg 1997). There was an outbreak of the starfish *Acanthaster planci* off the southeast coast in 1972, and an attempt was made to eradicate the outbreak (Branham et al. 1972 in Grigg 1997). However, it appears that the starfish returned to its normal abundance level naturally over a period of several years (Grigg 1997).

Kahoolawe: Kahoolawe was used as a military target for live-firing and bombing for years, which resulted in high rates of sedimentation onto the reefs (Grigg 1997). The reefs are now in a state of recovery, since the bombing ceased in 1994. Interestingly, little ordinance can be found on any reefs around Kahoolawe today, suggesting rapid overgrowth by coral and/or high accuracy of the military target practice (Grigg 1997).

Hawaii: The island of Hawaii (the Big Island) is still geologically active. The reefs on this island are dramatically different on the windward and leeward coasts (Grigg 1997). Reefs on the windward side (except in Hilo Bay) are controlled by wave stress, and are characterized by early successional reef stages (i.e. scattered coral colonies or thin veneers on basalt foundations: Grigg 1997, J. Maragos pers. comm. in Green 1997). In contrast, rich coral reef communities exist along the sheltered leeward side of the island (Grigg 1997, J. Maragos pers. comm. in Green 1997). However, Grigg (1997) noted that the reefs along the leeward shore are subject to severe storms with a periodicity of approximately 40 years, which may explain why fringing reefs are not well developed in this area. Human impacts have also had some effect on the reefs of this island. Reefs on the Hamakua Coast have been degraded by sugar cane waste waters in the past, while excessive fishing, aquarium fish collecting and ground water intrusion have caused serious human impacts on the reefs on the leeward coast (Grigg 1997).

Kauai: Kauai is the oldest and wettest island in the MHI, and Grigg (1997) suggested that sedimentation may be responsible for the lack of well developed fringing reefs around most of the island. Grigg (1997) noted that the reefs that are most heavily impacted by sediments are those that are in shallow or enclosed areas that have restricted circulation. In contrast, the healthiest reefs were found on the exposed northeast and north coasts where the sediment is washed away by waves and currents (Grigg 1997, J. Maragos pers. comm. in Green 1997). Grigg (1997) also noted that some of the best reefs on the island exist in deep water (15-25m deep) in areas with the least exposure to sediment-laden streams (e.g. reefs of Poipu and Makahuena). However, these reefs have been impacted by hurricanes in recent years (Ewa in 1982 and Iniki in 1992: Grigg 1997). In addition to the recent reefs, fossil limestone reefs are present off the southern shore off Kauai (30-70m deep), where abundant populations of the black coral Antipathes dichotoma can be found (Grigg 1997). In addition to sedimentation, human impacts that are perceived to be a problem on the reefs of Kauai include high fishing pressure and poor water quality (Grigg 1997).

Niihau: Little is known about the reefs on the small, privately owned island of Niihau. However, they are believed to be in good condition, especially along the western coast (J. Maragos pers. comm. in Green 1997).

Penguin Bank: The reef habitat in Federal waters in the MHI is restricted to Penguin Bank and Kaula Rock (Hunter 1995). Very little is known of the condition of the reefs in these locations, although they are presumed to be in good condition because of their remoteness to human population areas. Based on interpretations of navigational charts, Hunter (1995) suggests that the Penguin Bank supports areas of coral or coralline algae at a depth of approximately 50 m. In deeper water (50-100m), the reef on Penguin Bank is characterized is dominated by coralline algae, Halimeda, bryozoans and pen shells, and corals are present in low abundances (Agegian & Abbott 1985 in Hunter 1995).

NWHI: The Northwestern Hawaiian Islands comprise a multitude of reef areas (Hunter 1995, Maragos and Gulko 2002), including: numerous islands or reefs (French Frigate Shoals, Kure, Laysan, Lisianski, Maro Reef, Midway Atoll , Necker Island, Nihoa Island, Pearl and Hermes Atoll, Gardner Pinnacles); two seamounts (Ladd and Nero); several banks (Brooks, Northhampton, Pioneer, Raita, Saint Rogatien, and Salmon); and eight shoals (Gambia Shoal and seven unnamed shoals, including three between Nihoa and Necker and one north of St. Rogatien). In general, these coral reef areas tend to be in excellent condition with unique biodiversity and high standing stock of many reef fishes, probably because of their isolation, protected status and harsh seasonal weather conditions (Friedlander 1996). The "pristine" condition of this resource is likely to continue, because they are distant from land based sources of pollution as well as protected from any large-scale human activities in the region (Friedlander 1996, Maragos and Gulko 2002).

Many reefs in the NWHI are comprised of calcareous algae (Green 1997). A peak in coral species diversity occurs in the middle of the Hawaiian Archipelago at FFS and Maro Reef (Grigg 1983). In general, fish species diversity appears to be lower in the NWHI than in the MHI. Although the inshore fish assemblages of the two regions are similar, fish size, density and biomass is higher in the NWHI and fish communities in the NWHI are dominated by apex predators (sharks and jacks), whereas those in the MHI are not (Friedlander and DeMartini 2002). Some fish species that are common in parts of the NWHI are rare in the MHI (Green 1997).

Deep Reef Slope, Banks, and Seamount Habitat

Within the Hawaii Archipelago, there are numerous banks and seamounts, with more observed in the NWHI rather than in the MHI. In the MHI, the largest bank is Penguin Bank which is located southeast of Oahu.

Pelagic Habitat

The archipelago's position in the Pacific Ocean lies within the clockwise rotating North Pacific Subtropical Gyre, extending from the northern portion of the North Equatorial Current into the region south of the Subtropical High, where the water moves eastward in the North Pacific Current. At the pass between the MHI and the NWHI there is often a westward flow from the region of Kauai along the lee side of the lower NWHI. This flow, the North Hawaiian Ridge Current (NHRC), is extremely variable and can also be absent at times. The analysis of 10 years of shipboard acoustic Doppler current profiler data collected by the NOAA Ship Townsend Cromwell shows mean flow through the ridge between Oahu and Nihoa, and extending to a depth of 200 m. (J. Firing pers. comm.).

Imbedded in the mean east-to-west flow are an abundance of mesoscale eddies created from a mixture of wind, current, and sea floor interactions. The eddies, which can rotate either clockwise or counter clockwise, have important biological impacts. For example, eddies create vertical fluxes, with regions of divergence (upwelling) where the thermocline shoals and deep nutrients are pumped into surface waters enhancing phytoplankton production, and also regions of convergence (downwelling) where the thermocline deepens. Sea surface temperatures around the Hawaiian Archipelago experience seasonal variability, but generally vary between 18°-28° C (64°-82° F) with the colder waters occurring more often in the NWHI.

A significant source of interannual physical and biological variation around Hawaii are El Niño and La Niña events. During an El Niño, the normal easterly trade winds weaken, resulting in a weakening of the westward equatorial surface current and a deepening of the thermocline in the central and eastern equatorial Pacific. Water in the central and eastern equatorial Pacific becomes warmer and more vertically stratified with a substantial drop in surface chlorophyll.

Physical and biological oceanographic changes have also been observed on decadal time scales. These low frequency changes, termed regime shifts, can impact the entire ocean ecosystem. Recent regime shifts in the North Pacific have occurred in 1976 and 1989, with both physical and biological (including fishery) impacts (Polovina, 1996; Polovina et al., 1995). In the late 1980's an ecosystem shift from high carrying capacity to low carrying capacity occurred in the NWHI. The shift was associated with the weakening of the Aleutian Low Pressure System (North Pacific) and the Subtropical Counter Current. The ecosystem effects of this shift were observed in lower nutrient and productivity levels and decreased abundance of numerous species in the NWHI including the spiny lobster, the Hawaiian monk seal, various reef fish, the red-footed booby, and the red-tailed tropic bird (Polovina and Haight, 1999; Demartini et. al., 2002).

3.5.4.2 Protected Species

Sea Turtles

Green and hawksbill turtles are known to occur in nearshore waters around Hawaii, and loggerhead, leatherback and olive ridley turtles have been incidentally caught by Hawaii-based pelagic longline vessels (NMFS 2005).

Leatherback Sea Turtles: Leatherback turtles are not known to nest in the Hawaiian Islands however anecdotal reports indicate they have been sighted with EEZ waters (NMFS 2001).

Loggerhead Sea Turtles: Loggerhead turtles are not known to nest or routinely occur in or around the Hawaiian Islands however at least four individuals were sighted in nearshore waters between 1979 and 1998 (NMFS & USFWS 1998b).

Green Sea Turtles: The Hawaii population of sea turtles is the only Pacific population known to be increasing, with both the foraging population and nesting populations showing 30 year increasing trends (Balazs and Chaloupka 2004).

Hawksbill Sea Turtles: Hawksbill turtle are known to reside and nest in the Main Hawaiian Islands, primarily on several small beaches on the islands of Hawaii (Balazs et al.1992, Katahira et al. 1994). Although the local population has increased there are still only a few dozen nesters each year (Balazs 2002).

Olive Ridley Sea Turtles: There have been two reports of single nests in Hawaii. The first was in 1985 on Maui but the eggs did not hatch (Balazs and Hau 1986) and the second was in 2002 on the island of Hawaii.

Marine Mammals

Humpback Whales: Humpback whales occur off all eight Hawaiian Islands during the winter breeding season, but particularly within the shallow waters of the "four-island" region (Kaho'olawe, Molokai, Lanai, Maui), the northwestern coast of the island of Hawaii, and the waters around Niihau, Kauai and Oahu.

Hawaiian Monk Seals: Monk seals are found at six main reproductive sites in the NWHI: Kure Atoll, Midway Island, Pearl and Hermes Reef, Lisianski Island, Laysan Island and French Frigate Shoals. Smaller populations occur on Necker Island, and Nihoa Island and NMFS researchers have also observed monk seals at Gardner Pinnacles and Maro Reef. The 2004 US Pacific Marine Mammal Stock Assessment estimates that there are 1,304 monk seals in the Hawaiian Islands with at least 52 of those occurring in the Main Hawaiian Islands (NOAA 2005).

Other Marine Mammals: Sperm whales, rough-toothed dolphins, Risso's dolphins, bottlenose dolphins, pantropical spotted dolphins, spinner dolphins, striped dolphins, pygmy killer whales, killer whales, melon-headed whales, short-finned pilot whales, Bryde's whales, Blainsville's beaked whales and pygmy sperm whales are known to occur around Hawaii.

Seabirds

Seabirds known to occur around Hawaii include short-tailed, black-footed and Laysan albatrosses, Christmas, Newell's, flesh-footed, wedge-tailed and sooty shearwaters, and masked, brown and red-footed boobies.

3.5.4.3 Fisheries

Under the authority of the MSA, the Council established (approved Secretary of Commerce approved) thresholds to determine overfishing (i.e. fishing mortality) and overfished (stock biomass) conditions for fisheries of the Western Pacific Region. Since 2000, the NWHI lobster fishery has been closed due to uncertainty in lobster stock assessments. On December 15, 2004 the Council was notified by letter that the Secretary of Commerce had determined on June 14, 2004 that overfishing of bigeye tuna (*Thunnus obesus*) was occurring Pacific-wide. The Council has until June 14, 2005 to take appropriate actions to reduce fishing mortality of bigeye tuna within its jurisdiction. On May 25, 2005, it was determined that the Hawaii Archipelago multi-species botttomfish complex was subject to overfishing as defined in the MSA, with the MHI the area where the overfishing problem primarily occurs (70 FR 34452, June 14, 2005). The Council was given one year to take action to end overfishing and is now considering a range of alternatives to meet this requirement. That action and those alternatives are the subject of a separate Federal action and NEPA analysis.

3.5.4.3.1 Demersal Fisheries

Coral Reef: In recent decades, there has been a notable decline in nearshore fishery resources in the MHI (Shomura 1987). Excessive fishing is considered to be one of the major causes of this decline (Grigg 1997; Harman and Katekaru 1988), coastal construction, sedimentation, and other effects of urbanization have also caused extensive damage to coral reefs and benthic habitat near the populated islands.

The majority of the total commercial catch of inshore fishes, invertebrates, and seaweed comes from nearshore reef areas around the MHI. Nearshore reefs in the MHI are the focus for commercial reef ornamentals harvesting and black coral collecting (Friedlander 1996).

Although precise fishing locations are not reported, fishing gear types that mainly target inshore and coastal pelagic species accounted for about 10% (or 1.5 million lbs.) of total annual commercial fish catches from 1990 to 1995. Recreational and subsistence catches are not reported in Hawaii, but creel surveys at Kaneohe, Hanalei, and Hilo Bays suggest that these catches are at least equivalent to the reported commercial catch, and may be two or three times greater (Friedlander 1996).

Commercial catches of coral reef fish include surgeonfishes (20%), goatfishes (13 %), squirrelfishes (11 %), unicornfishes (8 %), and parrotfishes (8 %) (DeMello 2004). Crabs, octopus, seaweed, limpets and other types of coral reef associated species are also harvested regularly.

There is a long history of coral reef fishing in the NWHI. Iverson et al. (1989) found ample evidence of fishing by the ancient Hawaiians as far north as Necker Island. Starting in the 1920s, a handful of commercial boats ventured into the NWHI to fish for shallow and deepwater bottomfish, spiny lobsters, and other reef and inshore species. Black-lipped pearl oysters at Pearl and Hermes Reef in the NWHI were overfished in the late 1920s and although there seems to be some pearl oyster recruitment occurring, the population has not recovered to pre-exploitation levels (E. Keenan pers. comm. 2005). From the late 1940s to the late 1950s, there was a large commercial fishery for akule and reef fish around French Frigate Shoals and Nihoa Island.

During the 1960s, and as recently as 1978, Asian fleets harvested tuna, billfish, precious corals, and groundfish in and around the NWHI using longliners, pole-and-line vessels, draggers, and trawlers. Foreign fishing in now prohibited throughout the archipelago. Currently there are no active coral reef fisheries in the NWHI.

Crustaceans: Ula (lobster) was a traditional source of food for Native Hawaiians and was sometimes used in early religious ceremonies (Titcomb 1978). After the arrival of Europeans in Hawaii, the lobster fishery became by far the most productive of Hawaii's commercial shellfish fisheries. It was reported that the MHI commercial lobster catch in 1901 was 131,200 lbs (Cobb

1902). By the early 1950s, the commercial catch of spine lobsters (*P. penicillatus*) around the MHI had dropped by 75% to 85% (Shomura 1987).

In the late 1970s NMFS, the U.S. Fish and Wildlife Service, Hawaii's Division of Aquatic Resources, and the University of Hawaii's Sea Grant Program joined in a cooperative agreement to conduct a five-year assessment of the biotic resources of the NWHI. The survey reported that Necker Island and Maro Reef had sufficiently large stocks of lobsters to support some commercial exploitation (Uchida and Tagami 1984).

Shortly after, several commercial vessels began lobster trapping operations. A period of low catches was followed by a rapid increase in landings as more vessels entered the fishery and markets were developed (Polovina 1993). In the mid-1980s, the NWHI lobster fishery was Hawaii's most lucrative fishery (Pooley 1993b).

Trapping activity fell in 1987 principally due to the exit of several large vessels from the fishery (Samples and Sproul 1988), but landings reached a record high in 1988 when wind and sea conditions allowed for an extended period of fishing in the upper bank areas where spiny lobsters tend to congregate (Clarke 1989).

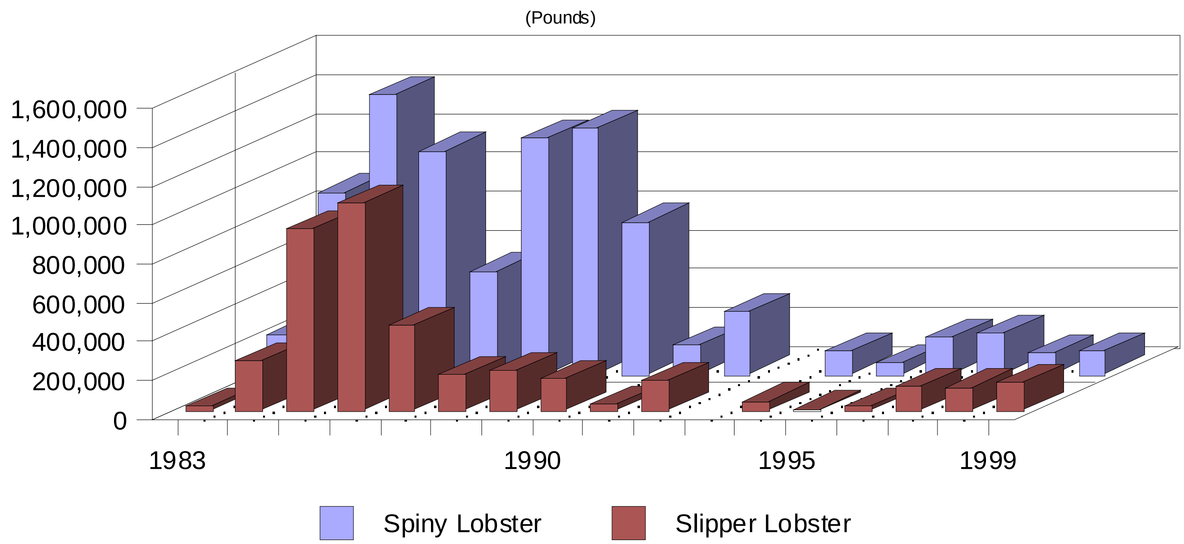
In 1990, however, lobster catch rates fell dramatically, although overfishing is not thought to be responsible for the decline (Polovina and Mitchum 1992). Rather, the decrease was found to be likely due to a climate-induced change in oceanic productivity (Polovina et al. 1994). Nevertheless, the 1990 season showed that there was excessive fishing capacity in the industry given the reduced population size (Polovina and Haight 1999). Responding to this concern, the Council established a limited access program and a fleet-wide seasonal harvest guideline or quota in 1991 that significantly altered fishing operations (Kawamoto and Pooley 2000).

From 1992 through 1997, Necker Island accounted for 48% to 64% of the total NWHI lobster fishery effort and Gardner Pinnacles and Maro Reef accounted for most of the rest (WPRFMC 1999b). In 1998, separate harvest guidelines were calculated for each of four fishing areas (Necker Island Lobster Grounds, Gardner Pinnacles Lobster Grounds, Maro Reef Lobster Grounds and General NWHI Lobster Grounds) to prevent localized depletion. Since 2000 NMFS has not issued harvest guidelines for the NWHI lobster fishery due to uncertainty in their lobster stock assessment model and resultant concerns about the potential for overfishing.

By 1999 all participants in the NWHI lobster fishery used a plastic dome-shaped, single-chambered traps with two entrance funnels located on opposite sides. By regulation all traps escape vents to allow unwanted organisms to exit. The traps are typically fished in strings of several hundred that are set before sunset in depths from 20 to 70 m, and retrieved the next day. Both spiny and slipper lobsters may be caught in the same trap, but fishermen can affect the proportion of each species by selecting the trapping area and depth (Polovina 1993). Almost all lobsters harvested from the NWHI were sold as a frozen tails, however, from 1996 to 1998 the fleet also landed a significant quantity of live lobsters.

Between 1985 and 1991, total landings showed varying trends and beginning in 1992 landings were capped by the harvest guidelines (Figure 16).

Figure 16: NWHI Lobster Fishery Landings 1983-1999
(source: PIFSC 2003)



Non-targeted species account for a small percentage of the total catch in the NWHI lobster fishery, as the traps are designed for high selectivity. Using data from 1976-1991 (wire traps) and 1986-2003 (plastic traps) from research cruises in the NWHI, Moffit et. al (2005) examined the diversity of catch composition. The traps used for the research were more conservative than commercial traps as they did not have escape vents but otherwise they conformed to fishery regulations. Both wire and plastic traps were found to be highly selective, that is, they primarily caught lobsters. Wire traps caught a total of 82 species over the study period, of which the two target species of lobsters accounted for 90.5% by number. Plastic traps caught a total of 258 species of the study period of which 73.1% by number were the two target species. Because lobsters are one of the larger organisms captured, they would be a much higher percentage of the total catch if measured by weight. Of the organisms which were caught incidentally, hermit crabs made up the largest component followed by moray eels and small reef fish.

Octopus abundance was also evaluated due to its potential as a prey species for the Hawaiian monk seal. A total of 83 individuals were captured during the entire 1986-2003 study period and examination of the data showed no significant decline or increase in their capture rate over time. Based on the data, the study found that it is unlikely that lobster trapping activities have lowered octopus abundance to such a degree that monk seal populations would be negatively impacted (Moffit et al. 2005).

Overall, Moffit et al. (2005) concluded that lobster trapping activities are responsible for changes in abundance of a few species (target species have declined and some crab species have increased due to competitive replacement) of the benthic community in the NWHI, but do not appear to have resulted in major changes to the ecosystem. Moffit et. al. also state that gear lost in this fishery has not been found to be ghost fishing (still catching organisms), and that although direct damage to the benthic habitat by the traps has not been studied, it is not likely to be substantial due to the low relief, hard substrate that characterizes the fishing grounds. Since 1999, the NWHI lobster fishery has not operated due to uncertainties in accurate lobster stock assessments.

Bottomfish :Bottomfish fishing was a part of the economy and culture of the indigenous people of Hawaii long before European explorers first visited the islands. Descriptions of traditional fishing practices indicate that Native Hawaiians harvested the same deep-sea bottomfish species as the modern fishery and used some of the same specialized gear and techniques employed today.

The deep-slope bottomfish fishery in Hawaii concentrates on species of eteline snappers (e.g. opakapaka), carangids (e.g. jacks), and a single species of grouper (hapuupuu) concentrated at depths of 30-150 fm. The fishery can be divided into two geographical areas: the inhabited MHI with their surrounding reefs and offshore banks; and the NWHI, a 1,200 nm chain of largely uninhabited islets, reefs and shoals. In the MHI approximately 80% of the bottomfish habitat lies in state waters. Bottomfish fishing grounds within Federal waters around the MHI include Middle Bank, most of Penguin Bank and approximately 45 nm of 100-fathom bottomfish habitat in the Maui-Lanai-Molokai complex. For management purposes the NWHI fishery has been separated into the closer Mau Zone between 165° W and 161°20' W, and the more northwestern Hoomalu Zone to the west of 165°W.

In the small boat bottomfish fishery that is active around the MHI the distinction between recreational and commercial fishermen is extremely tenuous, with many otherwise recreational fishermen selling small amounts of fish to cover trip expenses. The number vessels used each year to target bottomfish in MHI varies between 250-500. Commercial fishermen in the MHI often concentrate their bottomfish fishing effort during December, when they can take advantage of the year-end holiday demand for red snappers.

In contrast bottomfish fishing in the NWHI is conducted solely by commercial fishermen and the vessels used tend to be larger than those fishing around the MHI, as the distance to fishing grounds is greater. Participation in the NWHI bottomfish fishery is controlled through limited access programs in each of the two management zones (Mau and Hoomalu). These zones were established to reduce the risk of biological overfishing and to improve the economic health and stability of the bottomfish fishery in the NWHI. The programs provide for a limited number of fishing permits to be issued each calendar year. Permits may not be sold, leased, or chartered. Based on the biological, economic, and social characteristics of the bottomfish fisheries in the two zones, the long-term target fleet sizes for the Hoomalu and Mau Zones have been determined to be 7 and 10 vessels, respectively. In 2004, four vessels fished in the Hoomalu Zone, and five vessels fished in the Mau Zone. All of these vessels are independent, owner-operated fishing operations.

Bottomfish gear and fishing strategies are highly selective for desired species and sizes. In addition, the use of bottom trawls, bottom gillnets, explosives and poisons is forbidden under the Bottomfish and Seamount Groundfish FMP.

Based on recent (1998-2002) harvest data, commercial bottomfish catches in the MHI fishery represent approximately 60 percent of the total commercial bottomfish harvest in Hawaii (WPRFMC 2004). Preliminary data for 2003 indicate that a total of 272,569 lbs of commercial landings were made by 325 vessels in the MHI, with a total ex-vessel value of $1,460,000 (Figures 17 and 18). Mau Zone landings for 2003 were estimated to total 77,000 lbs, with a total ex-vessel value of $356,769, while Ho'omalu Zone landings were 145,000 lbs with a total ex-vessel value of $494,450 (WPRFMC 2005).

Figure 17: MHI and NWHI Bottomfish Landings 1986-2003
(source: WPFMC 2004)

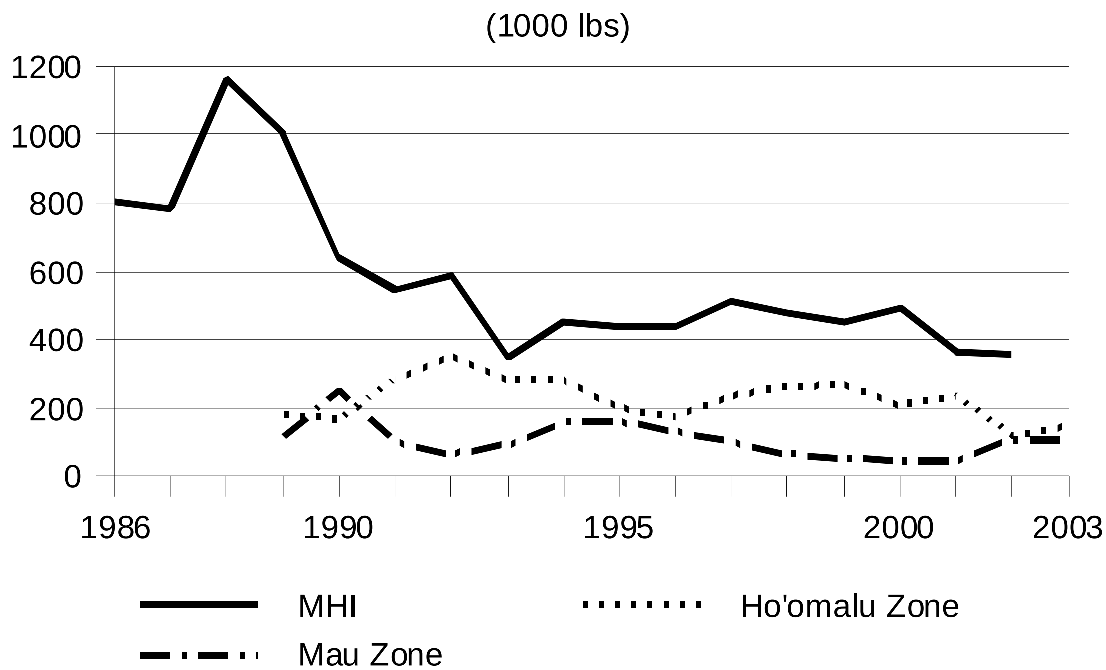
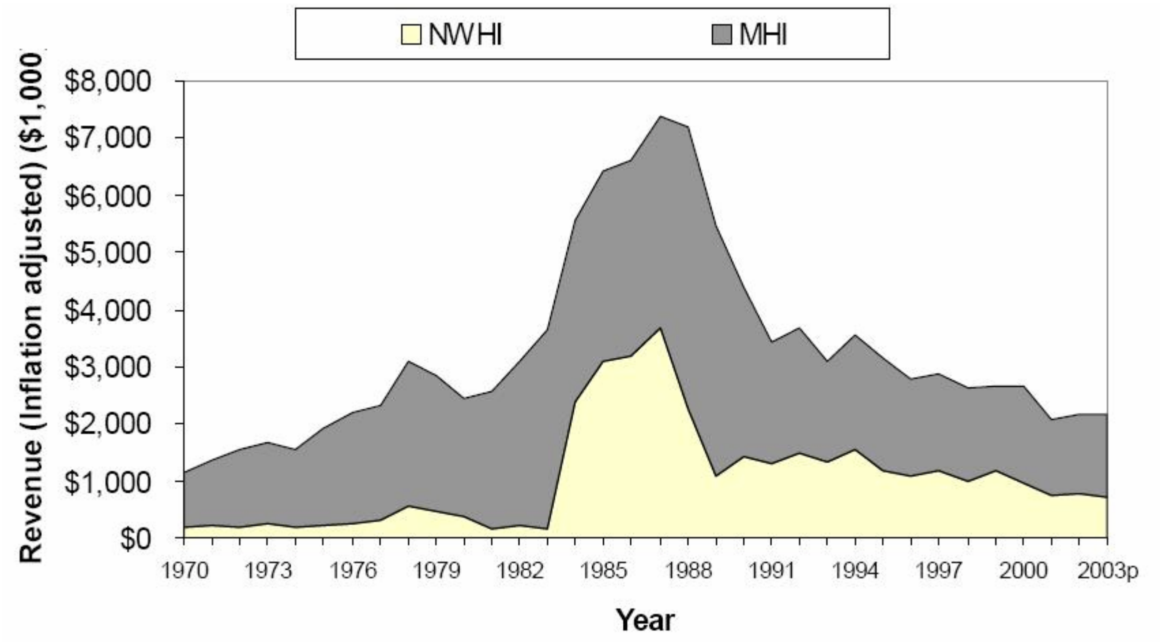


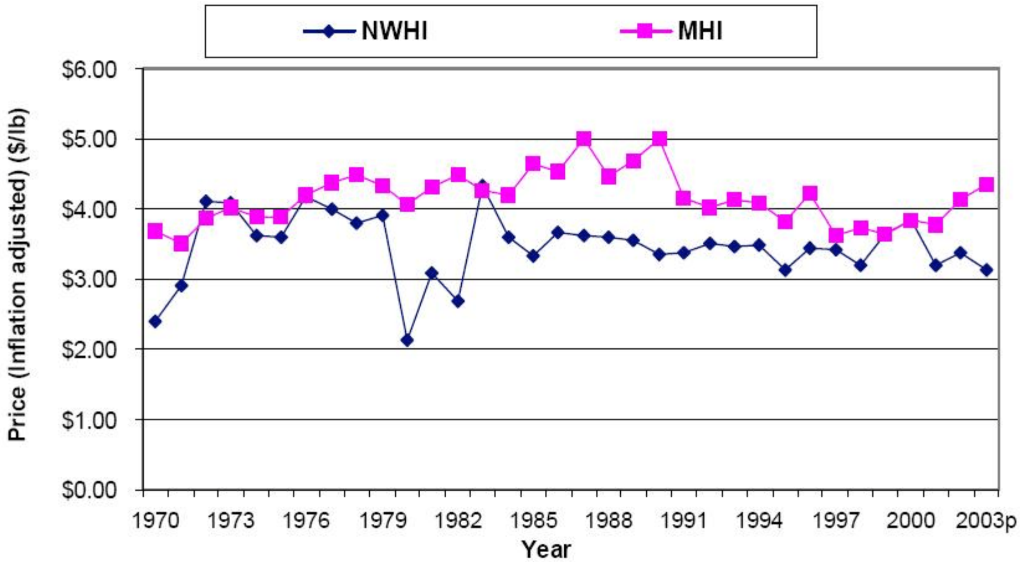
Figure 18: Hawaii Bottomfish Revenue (inflation adjusted) By Area 1970-2003
(source: WPFMC 2004)



Nearly all bottomfish caught in the NWHI fishery are sold through the Honolulu fish auction (United Fishing Agency, Ltd.). Bottomfish caught in the MHI fishery are sold in a wide variety of market outlets (Haight et al. 1993b). Some are marketed through the fish auction and intermediary buyers on all islands. Sales of MHI bottomfish also occur through less formal market channels such as local restaurants, hotels, grocery stores and to individual consumers. Unsold fish are consumed by fishermen and their families, given to friends and relatives as gifts, and bartered in exchange for various goods and services.

Onaga and opakapaka comprise the largest valued landings in each area for most years (ignoring the highly fluctuating landings of uku); NWHI ex-vessel prices were \$4.53 and \$4.79 per pound respectively in 2003 while MHI were \$5.89 and \$5.01, respectively. However, the NWHI landings are comprised of a higher percentage of these higher priced species compared to the MHI, so the difference in price for individual species by area is ironed out by the different species compositions between the two areas (see Figure 19).

Figure 39: Average Prices for NWHI and MHI BMUS Landings 1970-2003
(source: WPFMC 2004)



According to U.S. Customs data for the Port of Honolulu, 801,000 pounds of snapper were imported in 2003 worth $2.26 million ($2.82 per pound). This exceeded the domestic supply and thus was a significant factor in ex-vessel prices (WPFMC 2004). Tonga and Australia were the largest sources of fresh snapper, with Fiji and New Zealand also being major sources. Not only has the quantity of foreign-caught fresh fish increased during the last few years, but the number of countries exporting fresh fish to Hawaii has also increased. A decade ago, for example, fresh snapper was exported to Hawaii mainly from within the South Pacific region. In recent years Tonga and Australia were the largest sources of imported fresh snapper, with Fiji and New Zealand also being major sources, and Viet Nam, Chad (freshwater) and Madagascar as minor sources.

In 2005, it was determined that the Hawaii Archipelago multi-species botttomfish complex was subject to overfishing as defined in the MSA, with the MHI the area where the overfishing problem primarily occurs (70 FR 34452, June 14, 2005). The Council was given one year to take action to end overfishing and is now considering a range of alternatives to meet this requirement. That action and those alternatives are the subject of a separate Federal action and NEPA analysis.

Precious Corals: The collection of black coral from depths of 30-100 m by scuba divers has continued in Hawaii since black coral beds were discovered off Lahaina, Maui, in the late 1950s, although harvest levels have fluctuated with changes in demand. Since 1980, virtually all of the black coral harvested around the Hawaiian Islands has been taken from a bed located in the Au’au Channel. Most of the harvest has come from State of Hawaii waters and no black coral diver has ever received a Federal permit to harvest precious coral in the EEZ. However, a substantial portion of the black coral bed in the Au’au Channel is located in the EEZ. In 1999, concern about the potential for greater harvesting pressure on the black coral resources led the State of Hawaii to prohibit taking the harvest of black coral with a base diameter of less than 3/4 inches from state waters. The Council has recommended that a minimum size limit also be established for black coral harvested in the EEZ (WPRFMC 1999a).

After two decades of minimal activity, the domestic fishery for pink, gold and bamboo precious corals in the EEZ of Hawaii resumed in December 1999. One company used two one-man submersibles to survey and harvest pink and gold corals at depths between 400-500 m during 1999 and 2001, however they did not continue their operations after that time and the actual harvests cannot be reported here because of data confidentiality policies which prohibit the publication of proprietary information unless there are at least three separate operations included in the dataset.

In 1988, the domestic fishing vessel *Kilauea* used a tangle net dredge (now prohibited) to harvest beds at Hancock Seamount. Their catch, however, consisted mostly of dead or low quality pink coral and the operation was soon discontinued. In the mid 1980s, a company experimented with manned submersibles equipped with spotlights, cameras and a variety of maneuverable tools to harvest individual colonies, chosen by size and quality prior to cutting, in a highly controlled and efficient manner (Carleton 1987).

Between 1990 and 1997, the annual harvest of black coral in Hawaii varied from a low of 864 lbs to a high of 6,017 lbs, with a yearly average of 3,084 lbs (Table 21). Landings and ex-vessel values of the black corals recently harvested in Hawaii cannot be presented due to the low number of active harvesting operations (less than three).

Because the Precious Corals FMP allows harvest only by selective gear, i.e with submersibles or by hand, Federal precious coral fisheries in Hawaii have no bycatch.

Table 21: Volume and Value of Black Coral Landings in Hawaii 1990-1997
(source: Hawaii Division of Aquatic Resources)

YEAR	HARVESTED (LB)	SOLD (LB)	VALUE ($)
1990	2,349	2,169	31,575
1991	2,305	2,250	35,080
1992	2,398	2,328	46,560
1993	864	769	15,380
1994	4,354	4,209	84,180
1995	6,017	5,912	122,765
1996	4,865	1,703	41,325
1997	1,520	415	10,394

The naming of black coral as the Hawaii state "gem" in 1987 increased consumer interest in this precious coral (Grigg 1993). However, the quantity of black coral required by jewelry manufactures in Hawaii has dropped considerably because the jewelry items produced are smaller and of higher quality and because modern cutting procedures have become much more efficient (Carleton 1987). A worldwide glut of *Corallium* produced during the boom years of the early 1980s caused the market value of pink coral to fall (Grigg 1993). Consequently, many fishermen dropped out of the fishery and the worldwide supply of deep-water precious corals has dwindled. The precious corals jewelry industry in Hawaii has been estimated to be worth about $25 million at the retail level (Grigg 1993).

3.5.4.3.2 Pelagic Fisheries

Hawaii's pelagic fisheries, which include the longline, Main Hawaiian Islands troll and handline, offshore handline, and the aku boat (pole and line) fisheries; are the state's largest and most valuable fishery sector. The target species are tunas and billfish, but a variety of other species are also important. Collectively, these pelagic fisheries made approximately 23 million lbs of commercial landings with a total ex-vessel value of $48 million in 2003 (WPFMC 2003).

The largest component of pelagic catch in 2003 was tunas. Bigeye tuna was the largest component and has increased almost five-fold from its 1987 catch. Swordfish was the largest component of the billfish catch from 1990 through 2000, but was replaced by blue marlin in the next two years, and followed by striped marlin in 2003. Mahimahi was the largest component of the non-tuna and non-billfish catch though ono (wahoo) and moonfish catches rose to comparable levels.

Table 22: Hawaii Commercial Pelagic Catch, Revenue, and Average Price 2002-2003

	2002			2003		
Species	**Pounds caught (1000 lbs)**	**Ex-vessel revenue ($1000)**	**Average price ($/lb)**	**Pounds caught (1000 lbs)**	**Ex-vessel revenue ($1000)**	**Average price ($/lb)**
Tuna PMUS						
Albacore	1,670	$1,930	$1.17	1,340	$1,560	$1.16
Bigeye tuna	10,970	$28,480	$2.68	8,350	$25,780	$3.12
Bluefin tuna	2	$4	$8.22	1	$5	$9.64
Skipjack tuna	1,160	$1,210	$1.27	1,580	$1,330	$1.00
Yellowfin tuna	2,680	$5,960	$2.27	3,420	$8,620	$2.52
Other tunas	10	$9	$1.01	10	$4	$1.02
Tuna PMUS subtotal	**16,500**	**$37,600**	**$2.37**	**14,700**	**$37,300**	**$2.60**
Billfish PMUS						
Swordfish	720	$1,380	$1.96	320	$690	$2.22
Blue marlin	1,040	$1,020	$1.17	1,160	$820	$0.86
Striped marlin	610	$980	$1.60	1,370	$1,160	$0.84
Other marlins	390	$290	$0.88	580	$270	$0.52
Billfish PMUS subtotal	**2,800**	**$3,700**	**$1.45**	**3,400**	**$2,900**	**$0.93**
Other PMUS						
Mahimahi	1,420	$2,620	$1.91	1,340	$2,910	$2.22
Ono (wahoo)	690	$1,450	$2.20	1,000	$1,900	$1.94
Opah (moonfish)	920	$1,220	$1.34	1,090	$1,510	$1.38
Pomfrets	500	$680	$1.38	460	$780	$1.69
Oilfish	200	$290	$1.43	280	$420	$1.50
Sharks (whole weight)	350	$110	$0.41	340	$110	$0.37
Other pelagics	20	$10	$0.85	20	$20	$0.88
Other PMUS subtotal	**4,100**	**$6,400**	**$1.63**	**4,500**	**$7,700**	**$1.72**
Total pelagics	**23,400**	**$47,700**	**$2.14**	**22,600**	**$47,900**	**$2.18**

3.5.4.4 Communities

The most recent estimate of the contribution of the commercial, charter and recreational fishing sectors to the state economy indicated that in 1992, these sectors contributed $118.79 million of output (production) and $34.29 million of household income and employed 1,469 people (Sharma et al. 1999). These contributions accounted for 0.25% of total state output ($47.4 billion), 0.17% of household income ($20.2 billion) and 0.19% of employment (757,132 jobs). In contrast to the sharp decline in some traditional mainstays of Hawaii's economy such as large-scale agriculture the fishing industry has been fairly stable during the past decade. Total revenues in Hawaii's pelagic, bottomfish and lobster fisheries in 1998 were about 10% higher than 1988 revenues (adjusted for inflation) in those fisheries.

The Hawaii longline fishery is by far the most important economically, accounting for 77 percent of the estimated ex-vessel value of the total commercial fish landings in the state in 2003 (WPRFMC 2004).

Income generation in Hawaii is characterized by tourism, Federal defense spending and, to a lesser extent, agriculture. Tourism is by far the leading industry in Hawaii in terms of generating jobs and contributing to gross state product. The World Travel and Tourism Council (1999) estimates that tourism in Hawaii directly generated 134,300 jobs in 1999. This figure represents 22.6 percent of the total workforce.

For 2002, DBEDT estimates that direct and indirect visitor contribution to the state economy was 22.3%. A bit less than half of that (10.2%) was generated in Waikiki. Total visitor expenditures in Hawaii were $9,993,775,000. Tourism’s direct and indirect contribution to Hawaii’s Gross State Product in 2002 was estimated at $7,974,000,000, or 17.3% of the total. Directly and indirectly, tourism accounted for 22.3% of all civilian jobs, and 26.4% of all local and state taxes.

Also important to Hawaii’s economy are Department of Defense expenditures. Defense expenditures in Hawaii are expected to increase significantly in the near future due to the pending arrival of the Stryker force and the renovation and construction of military housing. As of late July 2004, Hawaii expected to receive $496.7 million in defense-related spending. When combined with funds earmarked for construction that are contained in a measure before the Senate, Hawaii stands to receive more than $865 million in defense dollars, which do not include funds for day to day operations or payroll (Inouye 2004).

Agricultural products include sugarcane, pineapples, nursery stock, livestock, and macadamia nuts. In 2002, agriculture generated a total of $510,672,000 in sales. Agricultural employment decreased from 7,850 workers in 2000 to 6,850 in 2003.

Table 23: Statistical Summary of Hawaii's Economy, 1995-1999, 2002
(source: DBEDT 1999, 2002; BOH 1999a)

CATEGORY	UNITS	1995	1996	1997	1998	1999	2002
Civilian Labor Force	Number	576400	590200	592000	595000	594800	582200
Unemployment	Percent	5.9	6.4	6.4	6.2	5.6	4.2
Gross state product in 1996 dollars	$ Millions	37963	37517	37996	38015	38047	38,839 (2001)
Manufacturing Sales	$ Millions	2045	1724.1	1468.8	NA	NA	NA
Agriculture (all crops and livestock)	$ Millions	492.7	494.6	486.5	492.6	512992	510672
Construction completed	$ Millions	3153.3	3196.4	2864.9	NA	NA	NA
Retail sales	$ Millions	15693.3	16565	16426	NA	NA	NA
Defense expenditures	$ Millions	3782.5	3883.5	4074.9	4103.7	4174.2	4293459

Median household income in Hawaii was calculated to be $30,040, or 97% of the national average in 2002. Hawaii per capita income as a percentage of the national average has fallen steadily since 1970 (DBEDT 2003). In 1999, 8% of Hawaii's families were below poverty level, compared to 9% nationally according to the 2000 Census. Civilian employment decreased from 411,250 in 1991 to 396,050 in 2002, which is a decrease from a 98% employment rate to a 96% rate.

For several decades Hawaii benefited from the strength of regional economies around the Pacific that supported the state's dominant economic sector and principal source of external receipts – tourism (BOH 1999a). In addition, industries of long-standing importance in Hawaii, such as the Federal military sector and plantation agriculture, also experienced significant growth. However, Hawaii's economic situation changed dramatically in the 1990s. The state's main tourist market, Japan, entered a long period of economic malaise that caused the tourism industry in Hawaii to stagnate. The post-Cold War era brought military downsizing. Tens of thousands of acres of plantation lands, along with downstream processing facilities, were idled by the end of the decade due to high production costs. Employment in Hawaii sugar production fell by 20% between 1990 and 1993 and by an additional 50% from 1994 to 1995 (Yuen et al. 1997). Net out-migration became the norm in Hawaii, notwithstanding the state's appeal as a place to live. In 1998, the state-wide unemployment rate was 6.2%, and unemployment on the island of Molokai reached 15% (DBEDT 1999).

As a consequence of the economic upheaval of the 1990s and the extensive bankruptcies, foreclosures and unemployment, Hawaii never entered the period of economic prosperity that many U.S. mainland states experienced. Between 1998 and 2000, Hawaii's tourism industry recovered substantially, mainly because the strength of the national economy promoted growth in visitor arrivals from the continental U.S. (Brewbaker 2000).

By 2002, an improving economy resulted in a statewide unemployment rate of 4.4%, with Molokai down to 8.6% (DBEDT 2003). Despite downswings in tourism in the last few years due to the events of September 11, 2001, the SARS scare, Japanese economic issues, and world political conditions, tourism in Hawaii is improving to the point that there were fears that there would not be enough hotel rooms to accommodate all the Japanese tourists who wanted to come for O Bon season in August 2004 (Schafers 2004).

However, efforts to diversify the economy and thereby make it less vulnerable to future economic downturns have met with little success. To date, economic development initiatives such as promoting Hawaii as a center for high-tech industry have attracted few investors and it seems unlikely that any new major industry will develop in Hawaii in the near future to significantly increase employment opportunities and broaden the state's economy beyond tourism, the military, and construction.

3.5.5 Pacific Remote Island Areas

The following sections provide detailed information on the physical, biological, and social environments of the PRIAs managed under this FEP.

3.5.5.1 Baker Island

Baker Island, which is part of the Phoenix Islands Archipelago, is located 13 miles north of the equator at 0° 13' N and 176° 38' W and approximately 1,600 nm to the southwest of Honolulu. It is a coral topped seamount surrounded by a narrow fringing reef which drops steeply very close to the shore. The total amount of emergent land area of Baker Island is 1.4 km² (CIA World Fact Book 2005).

<u>Coral Reefs</u>

Within the 10 fm curve, the potential coral reef area of Baker Island is estimated at 5.2 km² (Rohnman et al. in press). At Baker Island, the following numbers of coral reef associated organisms are reported to occur: 80 species of corals, 13 genera of algae, 241 species coral reef fishes (Brainard et. al 2005). Although environmental and anthropogenic stressors such as climate change and coral bleaching, diseases, tropical storms, and marine debris remain, the coral reef ecosystem around Baker Island appears to be healthy and productive (Brainard et al. 2005).

<u>Deep Reef Slope</u>

Baker Island is a seamount surrounded by a narrow fringing reef which drops steeply very close to the shore. To date, data on the habitat of Baker Island's deep reef slope and the marine life it supports are unavailable.

Pelagic Habitat

Due to its position near the equator, Baker Island lies within the westward flowing South Equatorial Current. Baker Island also experiences an eastward flowing Equatorial Under Current that causes upwelling of nutrient and plankton rich waters on the west side of the island (Brainard et. al 2005). Sea surface temperatures of pelagic EEZ waters around Baker Island are often near 30° C.[8] Although the depth of the mixed layer in the pelagic waters around Baker Island is seasonally variable, average mixed layer depth is around 100 m (R. Moffit, PIFSC, pers. comm.).

Sea Turtles

Green sea turtles have been observed foraging in the nearshore areas around Baker Island, however, they have been observed nesting on the island (Beth Flint, USFWS, pers. comm.). Other species of sea turtles may occur in the EEZ waters around Baker Island, but to date, data on what species or their abundance are not available.

Marine Mammals

A resident population of bottlenose dolphins are reported to occur near Howland and Baker Islands (Brainard et. al 2005). Although other cetaceans such as sperm whales are believed to occur around Baker Island, information on the types of species and their abundance is currently unknown. In the summer of 2005, researchers from the NMFS's Southwest Science Center conducted a cruise to record the occurrence of marine mammals around the PRIAs. The data from that research cruise is currently being analyzed.

Seabirds

Baker Island provides habitat for a wide variety of resident and migratory seabirds. The USFWS is currently compiling information on the number species of seabirds which utilize the island.

Social Environment

In the early nineteenth century, several whaling ships landed on the island, including the *Gideon Howard* for whose captain, Michael Baker, the island is named. Captain Baker later sold his rights to the island to the American Guano Company who extensively mined the island's phosphate deposits from 1859 to 1878. In 1935, American colonists attempted to settle the island and built dwellings, a lighthouse, as well as planting trees and shrubs[9]. The settlement was abandoned due to World War II. Baker Island was designated as a National Wildlife Refuge in 1936 and is administered by the USFWS. The Refuge boundary, established by the USFWS, extends from the shoreline seaward to 3 nm. The USFWS prohibits fishing within the Refuge boundaries. Currently, Baker Island is uninhabited. There is, designated in the Council's

[8] http://oceanwatch.pifsc.noaa.gov/
[9] http://www.janeresture.com/baker/

Coral Reef Ecosystem FMP (69 FR 8336), a no-take MPA from 0 to 50 fm around Baker Island.

3.5.5.2 Howland Island

Howland Island, which is also part of Phoenix Islands Archipelago, is located 48 miles north of the equator at 0° 48' N and 176° 38' W, and 36 nautical miles north of Baker Island. The island, which is the emergent top of a seamount, is fringed by a relatively flat coral reef that drops off sharply. Howland Island is approximately a mile and a half long and a half mile wide. The island is flat and supports some grasses and small shrubs. The total land area is 1.6 km^2 (CIA World Fact Book).

Coral Reefs

The potential coral reef area with the 10 fm curve of Howland is estimated 3.0 km^2 (Rohman et al. in press). At Howland Island, the following numbers of coral reef associated organisms are reported to occur: 91 species of corals, 9 genera of algae, 302 species coral reef fishes (Brainard et. al 2005). Although environmental and anthropogenic stressors such as climate change and coral bleaching, diseases, tropical storms, and marine debris remain, the coral reef ecosystem around Howland Island appears healthy and productive (Brainard et al. 2005).

Deep Reef Slope

Howland Island is a seamount surrounded by a narrow fringing reef which drops steeply very close to the shore. To date, data on the habitat of Howland Island's deep reef slope and the marine life it supports are unavailable.

Pelagic Habitat

Due to its position slightly north of the equator, Howland Island lies within the margins of the eastward flowing North Equatorial Counter Current and the margins of the westward flowing South Equatorial Current. Sea surface temperatures of pelagic EEZ waters around Baker Island are often near 30° C.[10] Although the depth of the mixed layer in the pelagic waters around Howland Island is seasonally variable, average mixed layer depth is around 70 m – 90 m (R. Moffit, PIFSC, pers. comm.).

Sea Turtles

Green sea turtles are likely to inhabit the nearshore reef areas of Howland Island. Their abundance as well as the occurrence of other sea turtles around Howland Island is currently unknown.

Marine Mammals

[10] http://oceanwatch.pifsc.noaa.gov/

A resident population of bottlenose dolphins are reported to occur near Howland and Baker Islands (Brainard et. al 2005). Although other cetaceans such as sperm whales are believed to occur in the EEZ around Howland Island, information on the types of species and their abundance is currently unknown. In the summer of 2005, researchers from the NMFS's Southwest Science Center conducted a cruise to record the occurrence of marine mammals around the PRIAs. The data from that research cruise is currently being analyzed.

Seabirds

Howland Island provides habitat for a wide variety of resident and migratory seabirds. The USFWS is currently compiling information on the number species of seabirds which utilize the island.

Social Environment

In 1924, Bishop Museum archaeologist Kenneth Emory discovered several Polynesian structures as well as stone paths and pits and therefore concluded that Baker Island was known to early Polynesians.[11] Throughout the whaling era of the early nineteenth century, several ships are believed to have landed at Howland Island. In 1857, Howland Island was claimed by the American Guano Company, which mined several hundred thousand tons of guano between 1857 and 1878. American colonists landed on the island in 1935 and later built a runway that was planned to be used by Ameila Earnhart on her circumnavigation flight in 1937. Earnhart was supposed to land on Howland on July 2, 1937 as a stopover during her flight from Lau, New Guinea to Oahu, Hawaii however, Earnhart never arrived nor was heard from again. The lighthouse at Howland Island is called Amelia Earnhart light.[12] In 1942, following attacks on the island by Japanese forces, the American colonists were removed. Since that time, the island has remained uninhabited. In 1976, management authority of the Refuge was transferred to the USFWS. The Refuge boundary around Jarvis Islands extends seaward from shoreline to 3 nm. The USFWS prohibits fishing within the Refuge boundaries. Currently, Howland Island is uninhabited. There is, designated in the Council Coral Reef Ecosystem FMP (69 FR 8336), a no-take MPA from 0 to 50 fm around Howland Island.

3.5.5.3 Jarvis Island

Jarvis Island, which is part of the Line Island Archipelago, is located at 0° 23' S, 160° 01' W and approximatley1,300 miles south of Honolulu and 1000 miles east of Baker Island. Jarvis Island is a relatively flat (15-20 ft beach rise), sandy coral island with a total land area of 4.5 km². It experiences a very dry climate with limited rainfall (CIA World Fact Book).

Coral Reefs

Jarvis Island is surrounded by a narrow fringing reef. The potential coral reef area with the 10 fm curve is estimated at 3.0 km² (Rohnman et al. in press). At Jarvis Island, the following numbers of coral reef associated organisms are reported to occur: 49 species of corals, 10

[11] http://www.bishopmuseum.org/exhibits/pastExhibits/1995/hawaiilo/hawbaker.html
[12] http://www.janeresture.com/howland/

genera of algae, 252 species coral reef fishes (Brainard et. al 2005). Although environmental and anthropogenic stressors such as climate change and coral bleaching, diseases, tropical storms, and marine debris remain, the coral reef ecosystem around Jarvis Island appears healthy and productive (Brainard et al. 2005).

Deep Reef Slope

Jarvis Island is surrounded by a narrow fringing reef which drops steeply very close to the shore. To date, data on the habitat of Jarvis Island's deep reef slope and the marine life it supports are unavailable.

Pelagic Habitat

Due to its position below the equator, Jarvis Island lies within the South Equatorial Current which runs in a westerly direction. Sea surface temperatures of pelagic EEZ waters around Jarvis Island are often 28°- 30° C.[13] Although depth of the mixed layer in the pelagic waters around Jarvis Island is seasonally variable, average mixed layer depth is around 80 m (R. Moffit, PIFSC, pers. comm.).

Sea Turtles

Green sea turtles are likely to inhabit the nearshore reef areas of Howland Island. Their abundance as well as the occurrence of other sea turtles around Howland Island is currently unknown.

Marine Mammals

A resident population of bottlenose dolphins are reported to occur near Jarvis Island (Brainard et. al 2005). Although other cetaceans such as sperm whales are believed to occur in the EEZ around Jarvis Island, information on the types of species and their abundance is currently unknown. In the summer of 2005, researchers from the NMFS's Southwest Science Center conducted a cruise to record the occurrence of marine mammals around the PRIAs. The data from that research cruise is currently being analyzed.

Seabirds

Jarvis Island provides habitat for a wide variety of resident and migratory seabirds. The USFWS is currently compiling information on the number species of seabirds which utilize the island.

Social Environment

Between 1859 and 1878, Jarvis Islands was extensively mined for its rich guano deposits by the American Guano Company. In 1889, Great Britain annexed the island and leased to a British mining company, which did not extract large amounts of guano. In 1935, American colonists reclaimed Jarvis as an American possession and built group of buildings which they named

[13] http://oceanwatch.pifsc.noaa.gov/

Millerstown. Jarvis was abandoned by the colonists due to attacks from Japanese forces during WWII and since 1976 it has been a National Wildlife Refuge administered by the USFWS. The Refuge boundary around Jarvis Islands extends seaward from shoreline to 3 nm. The USFWS prohibits fishing within the Refuge boundaries. There is, designated in the Council Coral Reef Ecosystem FMP (69 FR 8336), a no-take MPA from 0 to 50 fm around Jarvis Island.

3.5.5.4 Palmyra Atoll

Palmyra Atoll is comprised of approximately 52 islets surrounding three central lagoons. This low-lying coral atoll system is approximately 1,056 nm south of Honolulu and is located at 5° 53' N latitude and 162° 05' W longitude. Palmyra Atoll and Kingman Reef occur at the northern end of the Line Island Archipelago, situated halfway between Hawaii and American Samoa. Palmyra Atoll occurs in an area of high rainfall known as the Intertropical Convergence Zone (see Section 3.1.1.1).

Coral Reefs

Palmyra Atoll is surrounded by extensive reef flats on all sides. The potential coral reef area within the 10 fm curve around Palmyra Atoll is estimated at 47.2 km^2 (Rohnman et al. in press). At Palmyra Atoll, the following numbers of coral reef associated organisms are reported to occur: 170 species of corals, 13 genera of algae, 343 species coral reef fishes (Brainard et. al 2005). Palmyra Atoll is observed to have a higher diversity of corals, anemones, and fishes than other PRIAs because it is located within the eastward flowing Equatorial Counter Current which flows from areas in the western Pacific with high levels of biodiversity (Brainard et. al 2005).

Deep Reef Slope

Data on the deep reef slope around Palmyra and the marine life it supports are unavailable, however, the area of deep reef slope is not believed to be extensive.

Pelagic Habitat

Due to its relative proximity to the equator, Palmyra Atoll and Kingman Reef lie in the North Equatorial Counter Current which flows in eastward direction. Sea surface temperatures of pelagic EEZ waters around Palmyra Atoll are often 27°- 30° C.[14] Although the depth of the mixed layer in the pelagic waters around Palmyra Atoll is seasonally variable, average mixed layer depth is around 90 m (R. Moffit, PIFSC, pers. comm.).

Sea Turtles

Both green sea turtles and hawksbill sea turtles have been observed at Palmyra Atoll, with only the green sea turtle observed to nest on Cooper's Island, which is the largest island within the Palmyra Atoll system (USFWS 1998).

[14] http://oceanwatch.pifsc.noaa.gov/

Marine Mammals

Pilot whales and bottlenose dolphins have been observed in the lagoon of Palmyra (Fefer 1987), and the Hawaiian monk seal was sighted in 1990 (Redmond 1990). Melon headed whales, which primarily feed on squid, have been observed on the southwestern side of Palmyra Atoll. Palmyra’s southwestern side is likely an area of higher productivity than areas because the main channel into the lagoon is located there and is believed to be the major output source of nutrient-rich lagoon waters (Brainard et al. 2005).

Seabirds

Palmyra Atoll supports 29 species migratory seabirds and shorebirds and has the largest nesting colonies of red-footed boobies and black noddies in the central Pacific (USFWS 1998).

Social Environment

Palmyra has had an interesting history involving shipwrecks, pirates and buried treasure, and a double murder in the mid-1970’s. Palmyra first became an American possession when it was claimed by the American Guano Company in 1859. In 1862, King Kamehameha 1V claimed Palmyra for the Kingdom of Hawaii. In 1898, when the U.S. annexed the Territory of Hawaii, President McKinley also includes Palmyra Atoll. In 1912, a judge from Honolulu bought all of Palmyra Atoll which he later sold to the Fullard-Leo family. From 1940-1946, the U.S. Navy took control of Palmyra and used it as a naval aviation facility. In 1947, the U.S. Supreme Court returned ownership of Palmyra to the Fullard-Leo family from the U.S. Navy. In 1961, President Kennedy assigned the U.S. Department of Interior to have civil administration over Palmyra. In 2000, The Nature Conservancy bought Palmyra Atoll from the Fullard-Leo family, and currently manages it as a nature preserve. The USFWS also administers the island as a National Wildlife Refuge and asserts a 12 nm boundary around the atoll. There is, designated in the Council Coral Reef Ecosystem FMP (69 FR 8336), a low-use MPA from 0 to 50 fm around Palmyra Atoll.

3.5.5.5 Kingman Reef

Kingman Reef, which is located 33 nm northwest of Palmyra Atoll at 6° 23' N and 162° 24' W, is a series of fringing reefs around a central lagoon. Kingman Reef does not have any emergent islets that support vegetation. There is, designated in the Council Coral Reef Ecosystem FMP (69 FR 8336), a no-take MPA from 0 to 50 fm around Kingman Reef.

Coral Reefs

The potential coral reef area within the 10 fm curve Kingman Reef is estimated at 20.9 km^2 (Rohnman et al. in press). At Kingman Reef, 155 species of corals, 15 genera of algae, and 225 species of reef fishes are reported to occur (Brainard et al. 2005).

Deep Reef Slope

Data on the deep reef slope around Kingman Reef and the marine life it supports are unavailable, however, the area of deep reef slope is not believed to be extensive.

Pelagic Habitat

Due to its relative proximity to the equator, Palmyra Atoll and Kingman Reef lie in the North Equatorial Countercurrent which flow in a west to east direction. Sea surface temperatures of pelagic EEZ waters around Palmyra Atoll are often 27°- 30° C.[15] Although the depth of the mixed layer in the pelagic waters around Kingman Reef is seasonally variable, average mixed layer depth is around 80 m (R. Moffit, PIFSC, pers. comm.).

Sea Turtles

Green sea turtles and hawksbill sea turtles are likely found at Kingman Reef, as both species are found at nearby Palmyra Atoll.

Marine Mammals

Due to its close proximity to Palmyra Atoll, bottlenose dolphins, pilot whales, melon headed whales and other cetaceans are likely to occur around Kingman Reef.

Seabirds

Seabirds from which nest at Palmyra are likely to visit areas near Kingman Reef, however since there are no emergent islands at Kingman Reef, it is believed no seabirds nest there.

3.5.5.6 Johnston Atoll

Johnston Atoll is located at 16° 44' N latitude and 169° 31' W longitude and approximately 720 nm southwest of Honolulu. French Frigate Shoals in the NWHI is the nearest land mass (~ 450 nm to the northwest), and due to its is proximity to the Hawaiian Islands there is believed to genetic and larval connectivity between Johnston Atoll and the Hawaiian Islands. Johnston Atoll is an egg-shaped coral reef and lagoon complex residing on a relatively flat, shallow platform approximately 21 miles in circumference (205 $km^{2)}$. Johnston Atoll comprises four small islands totaling 2.8 km^2. Johnston Island, the largest and main island, is natural in origin, but has been enlarged by dredge and fill operations. Sand Island is composed of a naturally formed island (eastern portion) connected by a narrow, man-made causeway to a dredged coral island (western portion). The remaining two islands, North Island and East Island, are completely man-made from dredged coral (USAF 2004).

Coral Reefs

The potential coral reef area within the 10 fm curve of Johnston Atoll is estimated at 150 km^2 (Rohnman et al. in press). Johnston Atoll, which as 34 *Scleractinian* and

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[15] http://oceanwatch.pifsc.noaa.gov/

Hydrozoan corals present, has fewer coral species than are found in the Hawaiian Islands. The reef is composed of alternating sand/loose coral and live coral, with the most dominant coral species present being *Acropora*. The coral *Montipora* is also widely found. Approximately 300 species of fish have been recorded in the nearshore waters and reefs of Johnston Atoll. This number is smaller than that of other islands in the Central Pacific, and is likely due to Johnston Atoll's small size and remote location. One species of angelfish, *Centropyge nahackyi*, is endemic (USAF 2004).

Deep Reef Slope

Data on the deep reef slope around Johnston Atoll and the marine life it supports are unavailable, however, the area of deep reef slope is not believed to be extensive.

Pelagic Habitat

Sea surface temperatures of pelagic EEZ waters around Johnston Atoll are often 27°- 30° C.[16] Although the depth of the mixed layer in the pelagic waters around Johnston Atoll is seasonally variable, average mixed layer depth is around 80 m (R. Moffit pers. comm.).

Sea Turtles

Only green sea turtles have been observed at Johnston Atoll. It is estimated that nearly 200 green sea turtles forage near its southern shore, however, it is thought that green sea turtles do not nest on Johnston Atoll (USAF 2004).

Marine Mammals

The following marine mammals have been observed at Johnston Atoll: Hawaiian monk seal, humpback whale, Cuvier's beaked whale, spinner dolphin, bottlenose dolphin (USAF 2004).

Most marine mammals are observed near Johnston Atoll occur outside the lagoon, however a Cuvier's Beaked whale has been seen inside the lagoon. Nine Hawaiian monk seals were translocated to Johnston Atoll from Laysan Island in 1984, and one or two of these tagged seals have repeatedly been observed at Johnston Atoll (Raytheon 2000).

Seabirds

The following table provides a list of seabirds observed at Johnston Atoll.

Table 24 : Seabirds of Johnston Atoll (Source: USAF 2004)

Seabirds	Scientific name
Great Frigatebird	*Fregata minor*
Brown Booby	*Sula leucogaster*
Masked Booby	*Sula dactylatra*

[16] http://oceanwatch.pifsc.noaa.gov/

Red-footed Booby	*Sula sula*
Red-tailed Tropicbird	*Phaethon rubricauda*
White-tailed Tropicbird	*Phaethon lepturus*
Christmas Shearwater	*Puffinus nativitatis*
Wedge-tailed Shearwater	*Puffinus pacificus*
Bulwer's Petrel	*Bulweria bulwerii*
Sooty Tern	*Sterna fuscata*
Gray-backed Tern	*Sterna lunata*
White Tern	*Gygis alba*
Black Noddy	*Anous minutus*
Brown Noddy	*Anous stolidus*
Winter Residents	
Bristle-thighed Curlew	*Numenius tahitiensis*
Pacific Golden-Plover	*Pluvialis fulva*
Ruddy Turnstone	*Arenaria interpres*
Sanderling	*Calidris alba*
Wandering Tattler	*Heteroscelus incanus*
Blue-gray Noddy	*Procelsterna cerulea*

Social Environment

Although both the U.S. and Great Britain annexed Johnston Atoll in the mid-1850's, only the U.S. (American Guano Company) mined phosphates from the island (CIA World Fact Book). President Theodore Roosevelt designated Johnston Atoll as a wildlife refuge in 1926, and in 1934 the U.S. Navy administered the area. In 1948, Johnston Atoll was managed by the U.S. Air force, which in the 1950's 1960's used the area for high-altitude nuclear tests. Until the 2000, Johnston Atoll was managed by the U.S. Department of Defense as a storage and disposal site for chemical weapons. In 2004, clean up and closure of the storage and disposal facilities was completed. Today, the USFWS continues to manage Johnston Atoll as a National Wildlife Refuge, but does allow some recreational fishing within the Refuge boundary (0-3 nm). There is, designated in the Council Coral Reef Ecosystem FMP (69 FR 8336), a low-use MPA from 0 to 50 fm around Johnston Atoll.

3.5.5.7 Wake Island

Wake Island is located at 19° 18' N latitude and 166° 35' E longitude and is the northernmost atoll of the Marshall Islands Archipelago, located approximately 2,100 miles west of Hawaii. Wake Island has a total land area of 6.5 km^2 and is comprised of three atolls, Wake, Peale, and Wilkes.

Coral Reefs

The potential coral reef area within the 10 fm curve around Wake is estimated at 22.9 km^2 (Rohnman et al. in press). One hundred and twenty-four species of reef fish have been recorded at Wake as well as a diverse assemblage of commercially important species of tuna, snappers, jacks and groupers. Sharks, particularly the gray reef, are reportedly abundant. The giant clam (*T. maxima*) is reported to be abundant in the lagoon. Fishing is prohibited within the lagoon.

There is, designated in the Council Coral Reef Ecosystem FMP (69 FR8336) a low-use MPA from 0 to 50 fm around Wake Island.

Deep Reef Slope

Data on the deep reef slope around Wake Island and the marine life it supports are unavailable, however, the area of deep reef slope is not believed to be extensive.

Pelagic Habitat

Sea surface temperatures of pelagic EEZ waters around Wake Island are often 27°- 30° C.[17] Although the depth of the mixed layer in the pelagic waters around Wake Atoll is seasonally variable, average mixed layer depth is around 80 m (R. Moffit, PIFSC, pers. comm.).

Sea Turtles

Green sea turtles are believed to be present in the nearshore areas around Wake Island, however their abundance or the occurrence of other sea turtles are unknown.

Marine Mammals

Spinner dolphins, Pacific bottle-nose dolphins *(Tursiops truncatus*) and Cuvier's beaked whales are thought to occur at Wake Island

Seabirds

Wake Island supports a wide variety of both resident and migratory seabirds.

Social Environment

The written historical record provides no evidence of prehistoric populations on Wake Island, but Marshall Islanders occasionally visited Wake, giving it the name *Enenkio*. The island was annexed by the United States in 1899. Before the 1930's the only visitors were scientists and survivors of shipwrecks. The Navy received administrative control of Wake in 1934, and established an air base on the atoll in January 1941.Wake Island figured prominently in World War II and the Japanese overtook U.S. forces on Wake in 1941. The U.S. re-occupied the atoll after the war, and administrative authority was held by the Federal Aviation Administration until 1962, when it was transferred to the Department of the Interior, which in turn assigned authority to the U.S. Air Force. Since 1994, the Department of the Army has maintained administrative use of Wake Island. This area is closed to the public and permission is needed to enter the area. The USFWS is currently considering incorporating Wake Island as part of the NWR system. There is, designated in the Council Coral Reef Ecosystem FMP (69 FR 8336), a low-use MPA from 0 to 50 fm around Wake Island.

3.5.5.8 PRIA Fisheries

[17] http://oceanwatch.pifsc.noaa.gov/

PRIA Bottomfish Fishery: Most of the PRIA are protected both by their isolation as well as through their status as National Wildlife Refuges. Nevertheless, nearshore fishing is popular among the resident populations at Johnston Atoll and Wake Island. The catch at these locations is primarily surgeonfish, goatfish, rudderfish, wrasses, parrotfish and soldierfish (Irons et al, 1990). These are all management unit species of the Coral Reef Ecosystem FMP. Several outbreaks of ciguatera have been reported on Johnston which have been attributed to dredging operations. This has limited the take of fish for food, although catch and release is still common. Commercial fishing occurs at Palmyra Atoll and Kingman Reef and recreational fishing, through the Nature Conservancy, is being developed at Palmyra. The recent renovation of the air strip and construction of vessel reprovisioning facilities by a fishing venture may promote increased fishing activity in and around Palmyra and Kingman waters. Recent restrictions for pelagic and other fishing (NMFS 2001 Biological Opinion for the Pelagic Fishery and Department of Interior Secretarial Orders) could likely limit or prohibit this venture.

In 1998, two Hawaii-based troll and handline vessels, and one demersal longline vessel targeting sharks, fished in the EEZ around Palmyra and Kingman Reef. These vessels also targeted both pelagic and bottomfish species, including yellowfin and bigeye tuna, wahoo, mahimahi, deep slope snappers and sharks (WPRFMC 2000b). One vessel made seven trips to these areas in 1999, targeting the two-spot snapper, *Luganus bohar*, at Kingman Reef, of which they caught 40,000 pounds. The fishermen tested much of the catch for ciguatera without a single positive and shipped the catch to New York and Florida. They stopped fishing after results of a single specimen submitted for testing to the University of Hawaii's School of Medicine showed slight traces of ciguatera.

Very little bottomfish research has been conducted in the PRIA to date. An assessment was conducted at Johnston Atoll in 1965, looking at the effects of dredging. The Coral Reef Initiative of 1995-1996 conducted general assessments of the reefs surrounding the PRIA and a joint coral reef assessment investigation between the USFWS and NMFS Honolulu Laboratory is ongoing. Cruises to Howland, Baker and Jarvis Islands and to Palmyra atoll and Kingman reef were conducted in 2000, 2001 and 2002. These investigations are focusing on the status of the shallow-water habitat including percent of live reef coverage, biodiversity and reef species stock assessments. As the assessments are being conducted with towed-sled scuba techniques, the deep-water habitat, including many of the commercially valuable snappers, is still unknown. To date, no data has been published from these cruises.

PRIA Crustaceans Fishery: A few fishermen have expressed interest in fishing for lobsters in the PRIA and at least two have attempted it. In 1999, one vessel left Hawaii to explore the lobster fishery in Palmyra/Kingman waters. However, tropical lobsters (green spiny, *P. penicillatus*) do enter traps readily and the lobster harvest was unsuccessful as 800 traps were deployed and no lobsters were caught. They also dove on the reef to try to catch lobsters by hand, but were not much more successful and returned with about 20 tails. This venture was also believed to attempt to target the red crab (*Chaceon spp*.) but no information was made available. In addition, to the vessel targeted deep-water shrimp and red crab at 300-800 m around Palmyra and Kingman. Reportedly, the operation did not lose many traps and the catch per unit effort (CPUE) was very high, at approximately 30 kg/trap.

Pelagic Fisheries: As many tropical pelagic species (e.g. skipjack tuna) are highly migratory, the fishing fleets targeting them often travel great distances. Although the EEZ waters around Johnston Atoll and Palmyra Atoll are over 750 nm and 1000 nm (respectively) away from Honolulu, the Hawaii longline fleet does seasonally fish in those areas. For example, the EEZ around Palmyra is often visted by Hawaii-based longline vessels targeting yellowfin tuna, whereas at Johnston Atoll, albacore tuna is often caught in greater numbers than yellowfin or bigyeye tuna. Similarly, the U.S. purse seine fleet also targets pelagic species (primarily skipjack tuna) in the EEZs around some PRIA, specifically, the equatorial areas of Howland, Baker, and Jarvis Islands. The combined amount of fish harvested from these areas from the U.S. purse seine on average is less than 5 per cent of their total annual harvest.

3.6 Administration and Enforcement

3.6.1 Permitting

Under all five of the Council's FMPs (Coral Reef Ecosystems, Crustaceans, Bottomfish and Seamount Groundfish, Precious Corals, and Pelagics) permits are administered by NMFS PIRO Sustainable Fisheries Division.

Coral Reef Ecosystems FMP Permits

Under the Coral Reef Ecosystems FMP, permits are required to harvest certain coral reef ecosystem management unit species for which there is little or no information. Permits are also required to fish in all areas designated as low-use MPAs under the FMP. Currently, there are no coral reef permits issued by PIRO.

Crustaceans FMP Permits

Under the Crustaceans FMP, three permit areas exist: Permit Area 1 (limited entry 15 max)- the EEZ around the NWHI; Permit Area 2- the EEZ around the Main Hawaiian Islands; and Permit Area 3- the EEZ around American Samoa and Guam. Although, the NWHI lobster fishery is currently not operating, PIRO renewed 10 Permit Area 1 permits in 2004. For Permit Areas 2 and 3, there are one and four current permits issued by PIRO, respectively.

Bottomfish and Seamount Groundfish FMP Permits

Under the Bottomfish and Seamount Groundfish FMP, permits are required fish in the NWHI Bottomfish Management Area, which is separated by two limited access zones: Hoomalu Zone and Mau Zone. Currently, there are four active permits in the Hoomalu Zone and five active permits in the Mau Zone.

Precious Corals FMP Permits

Under the Precious Corals FMP, permits are required to harvest precious corals in the following areas: Makapuu (Oahu), Permit Area E-B-1, includes the area within a radius of 2.0 nm of a point at 21 deg.18.0[min] N. lat., 157 deg.32.5[min] W. long; Keahole Point (Hawaii), Permit

Area C-B-1, includes the area within a radius of 0.5 nm of a point at 19 deg.46.0[min] N. lat., 156 deg.06.0[min] W. long.; Kaena Point (Oahu), Permit Area C-B-2, includes the area within a radius of 0.5 nm of a point at 21 deg.35.4[min] N. lat., 158 deg.22.9[min] W. long.; Brooks Bank, Permit Area C-B-3, includes the area within a radius of 2.0 nm of a point at 24 deg.06.0[min] N. lat.,166 deg.48.0[min] W. long.; 180 Fathom Bank, Permit Area C-B-4, N.W. of Kure Atoll, includes the area within a radius of 2.0 nm of a point at 28 deg.50.2[min] N. lat., 178 deg.53.4[min] W. long.; Westpac Bed, Permit Area R-1, includes the area within a radius of 2.0 nm of a point at 23 deg.18' N. lat., 162 deg.35' W. long.; Permit Area X-P-H includes all coral beds, other than established beds, conditional beds, or refugia, in the EEZ seaward of the State of Hawaii; Permit Area X-P-AS includes all coral beds, other than established beds, conditional beds, or refugia, in the EEZ seaward of American Samoa; Permit Area X-P-G includes all coral beds, other than established beds, conditional beds, or refugia, in the EEZ seaward of Guam; and, Permit Area X-P-PI includes all coral beds, other than established beds, conditional beds, or refugia in the EEZ seaward of the U.S. Pacific Island possessions. Currently, there are only two active permits issued by PIRO for Western Pacific Region.

Pelagics FMP Permits

At this time, only participants in the longline fishery operating under the Pelagics FMP are required to have permits. The Hawaii-based longline fishery is a limited-access fishery with a maximum of 164 permits. Longline fisheries elsewhere in the region operate under a currently unlimited number of general longline permits. During 2002 (2002 Ann Rept), all 164 of the Hawaii-based permits were maintained, although 46 of these were held without vessels. In 2003, all 164 permits were maintained, 123 with vessels registered to them (PIRO, unpub. data).

There were also 88 active general longline permits, all for vessels based in American Samoa. In 2003, 66 General Longline Permits were issued, 64 for vessels in American Samoa, one in Guam and one in the CNMI (PIRO unpub. data)

A U.S. fishing vessel must be registered for use under general longline permit if that vessel is used: (1) to fish for PMUS using longline gear in the EEZ around American Samoa, Guam, the Northern Mariana Islands, or other U.S. island possessions in the Pacific Ocean; or (2) to land or transship, shoreward of the outer boundary of the EEZ around American Samoa, Guam, the Northern Mariana Islands or other U.S. island possessions in the Pacific Ocean, PMUS that were harvested with longline gear. In addition, a U.S. fishing vessel of the United States must be registered for use under a Hawaii longline limited access permit if that vessel is used: (1) to fish for PMUS using longline gear in the EEZ around Hawaii; or (2) to land or transship, shoreward of the outer boundary of the EEZ around Hawaii, PMUS that were harvested with longline gear. A receiving vessel must be registered for use with a receiving vessel permit if that vessel is used to land or transship, shoreward of the outer boundary of the fishery management area, PMUS that were harvested with longline gear.

In 2002, the Council recommended to the Secretary of Commerce Amendment 11 to the Pelagics FMP to create a limited access permit system for American Samoa. The objectives of this system are to avoid gear conflicts in the American Samoa EEZ outside of the 50 nm area closed to large longline vessels and to avoid overcapitalization in the fleet. On May 24, 2005 (70 FR 29646), NMFS issued the final rule to implement the American Samoa longline limited access program. The estimated maximum number of permits will be 138. To qualify for a permit an individual must have owned a vessel used to legally harvest PMUS in the EEZ around American Samoa prior to March 22, 2002. Permits would be established for four categories based on vessel length (less than 40 ft, 40-50 feet, 50-70 feet, and over 70 feet). "Upgrade permits" (26) will be available to permit holders in the smallest vessel size class. Vessels greater than 40 feet in length will be required to carry observers, if requested by NMFS, and vessels over 50 feet in length will be required to carry a Vessel Monitoring Unit (VMS) if request by NMFS.

3.6.2 Enforcement

The USCG patrols the region with C-130 aircraft and surface vessels, however, since 9/11 the Homeland Security mission has taken precedence over fisheries surveillance and enforcement activities. Enforcement for the Hawaii-based longline fishery is facilitated by use vessel monitoring system (VMS) operated by NMFS and USCG. A VMS is an automated real-time, satellite-based tracking system that obtains accurate and near-continuous position reports from vessels at sea. The VMS in Hawaii was established in 1994 to help enforce area closures around the Hawaiian Islands in which fishing with longline gear is prohibited. NMFS certifies the VMS system hardware and software aboard each vessel and assigns each VMS unit a unique identification number. VMS for the American Samoa longline limited access program will likely be implemented within 2006.

Special Agents of NMFS' Office of Law Enforcement (OLE) conduct investigations of alleged violations of NOAA statutes and regulations, including the Magnuson-Stevens Act, the Lacey Act, the Shark Finning Prohibition Act, the Marine Mammal Protection Act and the Endangered Species Act based on case packages forwarded from the Coast Guard.

3.6.3 Data Collection

Logbooks are an important source of fisheries dependent data. All permitted fisheries in the Western Pacific Region require the maintenance and submittal of a logbook to record catch information such as effort and location. Logbook information is collected and analyzed by the NMFS's Pacific Islands Fishery Science Center.

The Western Pacific Fishery Information Network (WPacFIN) is a Federal and state partnership for collecting, processing, analyzing, sharing and managing fisheries data from the Western Pacific Region. Through the cooperative efforts of the member agencies, WPacFIN provides fisheries data and information when, where, and in the quality needed by NMFS as well as the Council and its various support groups to develop, implement, evaluate and amend FMPs for the region. WPacFIN assists island agencies in designing and implementing appropriate local fisheries data collecting, monitoring, analyzing and reporting programs, complete with associated microcomputer-based data processing systems, and helps promote data standards to facilitate information analyses and reports. Brief descriptions of the fisheries data collection systems for the each island area are provided below.

Hawaii

State of Hawaii regulations require any person who takes marine life for commercial purposes, whether within or outside of the state, to first obtain a commercial marine license from the Hawaii Division of Aquatic Resources (HDAR). Every holder of a commercial marine license must furnish to HDAR a monthly catch report. Every commercial marine dealer must furnish to HDAR a monthly report detailing the weight, number and value of each species of marine life purchased, transferred, exchanged or sold and the name and current license number of the commercial marine licensee from whom the marine life was obtained.

NMFS formerly administered a fish market sampling program in Honolulu. In cooperation with the state, staff from both NMFS and HDAR visited the fish auction managed by the United Fishing Agency and obtained size frequency and economic data on pelagic fish and bottomfish sold. These data are now submitted electronically to HDAR by the auction as part of the commercial marine dealer reporting system.

American Samoa

Longline vessels are required to complete the NMFS Western Pacific Daily Longline Fishing Log. Catch data for other fishing methods are collected through the Offshore Creel Survey administered by the Department of Marine and Wildlife Resources (DMWR) of the American Samoa Government. Since 1985, the Offshore Creel Survey conducted on the island of Tutuila has examined both commercial and recreational boat trip catches at five designated sites. For two weekdays and one weekend day per week, DMWR data collectors sample offshore fishers between 0500 and 2100 hours. Two DMWR data collectors also collect fishing data on the islands of Tau and Ofu in the Manua Group.

Data on fish sold to outlets on non-sampling days or caught during trips missed by data collectors on sampling days are accounted for in a Commercial Purchase System (receipt book) or in the Cannery Sampling Form. A Daily Effort Census is used to monitor the activity of the longline fleet. A vessel inventory conducted twice a year provides data on other vessel numbers and fishing effort.

Guam

An Inshore and Offshore Creel Survey program administered by the Division of Aquatic and Wildlife Resources (DAWR) of the Government of Guam provides estimates of island-wide catch and effort for all the major fishing methods used in commercial and recreational fishing. In 1982, WPacFIN began working with the Guam Fishermen's Cooperative Association to improve their invoicing system and obtain data on all fish purchases on a voluntary basis. Another major fish wholesaler and several retailers who make purchases directly from fishers also voluntarily provide data to WPacFIN using the Commercial Fish Receipt Book Program. That program, however, is not yet mandatory for local fish vendors. Guam Fishermen's Cooperative Association has recently adopted a voluntary reporting system for its members. The Guam Department of Commerce also maintains a mandatory data submission program to monitor landings from foreign longliners transshipping their catch through Guam.

Northern Mariana Islands

The Division of Fish and Wildlife (DFW) of the Commonwealth of the Northern Mariana Islands monitors the commercial fishery by summarizing sales ticket receipts from commercial establishments (commercial purchase database collection system). DFW staff routinely distribute and collect invoice books from 80 participating local fish purchasers on the island of Saipan, including fish markets, stores, restaurants, government agencies and roadside vendors. Similar systems are being developed for Tinian and Rota. DFW also administers an Inshore Creel Survey program targeting shoreline fishers.

Observer Program

The mission of NMFS PIRO Observer Program is to observe and document all species caught, including sea turtles, seabirds, marine mammals, and to collect selected biological specimens.. More specifically, among other tasks, observers:

- identify protected species, target, and bycatch species by number and location;
- record incidental mortality and injury of sea turtles, and tally all sea turtle observations during fishing activity;
- dissect post-mortem marine species as instructed (gonads, stomachs, otoliths);
- record sea turtle life history data, and tag all live sea turtles without existing tags;
- record life history data on other selected marine species;
- collect data on vessel activity and fishing operations;
- review and enter all data into a computer data base when on-shore; and
- collection of bird/fishing vessel interaction data including observations of deployed deterrents.

NMFS observers have been deployed in the Hawaii-based longline fishery since February 1994. PIRO's Observer Program currently administers observers for the Hawaii-based longline fishery, and the NWHI bottomfish fishery. Starting in 2006, observers will be placed with the American Samoa-based longline fleet.